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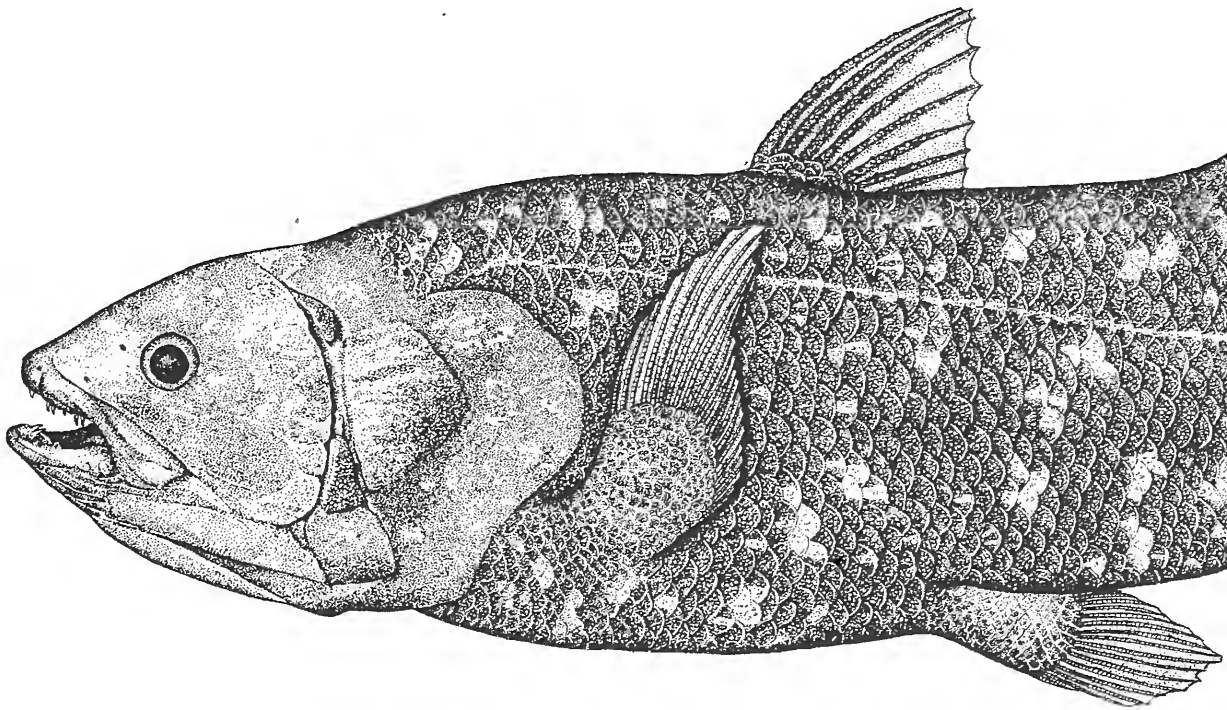
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Margaret Mary Smith (1916–1987),
James Leonard Brierley Smith (1897–1968)
with their dog Marlin

The publication series (Monographs, Bulletins & Special Publications) of SAIAB (formerly the JLB Smith Institute of Ichthyology), in its new format, honours James Leonard Brierley Smith and Margaret Mary Smith with the name Smithiana, in recognition of their many years of devoted service to African aquatic biology. Their life's work, a team effort, established modern ichthyology in southern Africa and laid the groundwork for the expansion of aquatic biology throughout the region.

SMITHIANA BULLETIN NO. 12

CONTENTS

A new species of blenny, *Cirripectes heemstraorum*, from Cape Vidal, South Africa (Family Blenniidae)

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ABSTRACT. *Cirripectes heemstraorum* sp. nov. is described from three specimens recently collected on the DAR 1 artificial reef in the iSimangaliso Wetland Park, off the east coast of South Africa at Cape Vidal. It is closely related to *C. auritus*, but is easily distinguished by its distinctive coloration. Females have a dark brown body with small spots over the posterior half to three quarters of the body and a brilliant yellow (pale in preservative) caudal fin; whereas in female *C. auritus* the body and the caudal fin are the same color with no contrasting dark to pale change between body and caudal fin. Male resembles female *C. heemstraorum*, but the caudal fin of males is dark brown basally with only the outer half of fin brilliant yellow (pale in preservative) and the small black spots on the caudal peduncle of the male coalesce into 2–3 short black stripes terminating on the base of the caudal fin. Male *C. auritus* lack black stripes at the base of the caudal fin and have the body and caudal fin uniformly dusky (pink, yellow or beige colored in life).

RÉSUMÉ. *Cirrripectes heemtraorum* sp. nov. est décrit à partir des trois exemples récemment retrouvées dans le DAR 1 un filon artificiel dans le iSimangaliso Wetland parc de la partie orientale de l'Afrique du Sud au Cap Vidale. C'est un tout peu comme la famille *C. auritus* mais c'est facilement distinctif par ses couleurs particulières. Les femelles ont un corps de couleur brun foncé avec de petites tâches dans la partie supérieure du corps et une couleur jaune brillant à la nageoire pendant que la femelle *C. auritus* a un corps et une nageoire de même couleur pas de contraste entre le noir et la couleur pâle entre le corps et la nageoire. Le mâle ressemble à la femelle *C. heemstraorum* mais la nageoire du mâle est fondamentalement brun foncé avec une moitié extérieure de la nageoire en jaune brillant (pâle de conservation) et de petites tâches noires sur la nageoire avec deux ou trois rayures noires au bout et sur le fond de la nageoire. Le mâle *C. auritus* par manque de rayures noires, a la partie inférieure de la nageoire et aussi le corps et la nageoire uniformément foncé (rose, jaune ou beige).

INTRODUCTION

Williams (1988) revised the Indo-Pacific blenniid fish genus *Cirripectes*, in which he recognized 21 species. Recent collections of fishes from Cape Vidal, KwaZulu-Natal, South Africa, include three specimens, a male and two females, similar in appearance to *C. auritus* Carlson, 1981. Unlike *C. auritus*, all three Cape Vidal specimens have dark brown bodies and brilliant yellow caudal fins in life (Fig. 1). Comparison of these specimens with specimens of *C. auritus* reveals that the Cape Vidal specimens represent an undescribed species currently known only from South Africa.

METHODS

Counts (when variable, values for each specimen are given separately with value of holotype in brackets): dorsal-fin elements consist of unsegmented, flexible rays (the last shortest) treated as spines (roman numerals) followed posteriorly by unbranched segmented rays (last spine and first segmented ray share common pterygiophore), posteriormost two rays borne by separate pterygiophores and counted as two rays; anal-fin elements include two flexible spines (spines of sexually mature males enveloped in fleshy rugosities); females with first of two spines embedded in swollen tissue behind gonopore (first spine visible only in osteological preparations) with second spine followed by flexible unbranched segmented rays, posteriormost ray of males and females appears as two rays split through the base, but borne by a single pterygiophore (terminal split ray counted as single ray); pelvic fins each with one greatly reduced, embedded spine (visible only in osteological preparations) and four segmented rays, innermost ray more slender and shorter than others, and closely applied to third ray making it difficult to distinguish; procurrent caudal-fin rays are small unsegmented rays located dorsally and ventrally in advance of segmented caudal-fin rays (middle nine segmented rays usually branched, upper two and lower two segmented rays simple); number of

vertebrae are presented as a formula, precaudal + caudal = total vertebrae; position of the last three anal-fin pterygiophores is given as a formula representing the number of pterygiophores occupying the last three pterygiophore-occupied interhemal spaces (1-1-2 means there is 1 pterygiophore in each of the 2 anterior spaces and 2 in the last space); nuchal cirri counts are of the number of cirri bases and the number of free tips for the fringe of cirri on the nuchal flaps; supraorbital and nasal cirri counts include all free tips (total of both sides); number of lateral line (LL) tubes includes only unconnected, bipored tubes on the left side (tubes begin at the end of the continuous part of the LL canal; the position of the last tube can be highly variable within a species); gill raker counts are of the total number of rakers on the first arch. Counts of the rays of the median fins and characters associated with the vertebral column (i.e. pleural ribs, epineurals, etc.) were taken from

radiographs. When the last anal-fin ray was split through its base, yet borne by one pterygiophore, it was counted as 1.

A pore position in a sensory pore series refers to all pores that can be traced back to a single branch from one of the main sensory canals of the cephalic lateralis system. Pore positions are characterized as simple (1 or 2 pores at each position), or complex (3 to 20 pores closely grouped together at each position; see Williams 1988: Fig. 6).

Method of taking measurements was conventional, but the soft bodies of the scaleless blennies make most measurements unreliable and of little or no taxonomic value due to their variability. SL refers to standard length.

Specimens are deposited in the South African Institute of Aquatic Biodiversity (SAIAB) and the Division of Fishes, National Museum of Natural History, Smithsonian Institution (USNM).
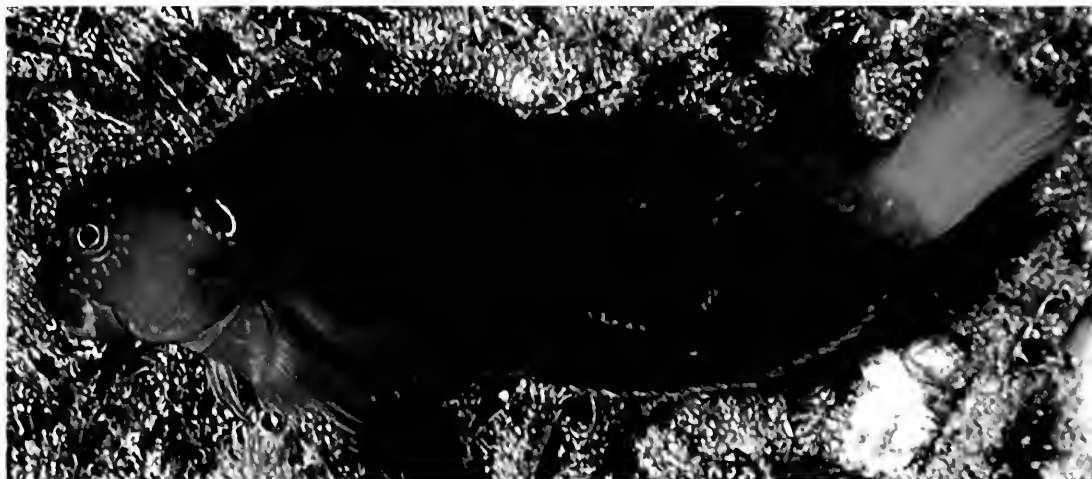

Fig. 1. Underwater photo of a female *Cirripectes heemstraorum* photographed by Dennis King on the DAR-1 artificial reef, iSimangaliso Wetland Park, Cape Vidal, South Africa.
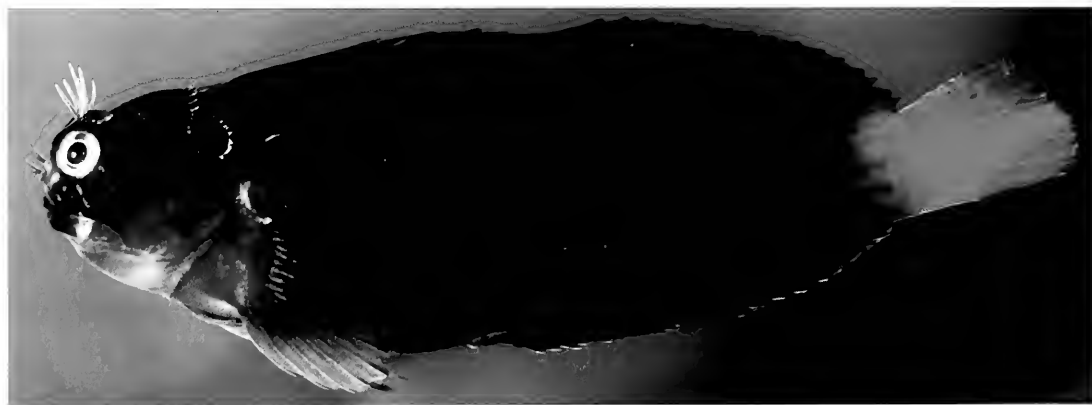

Fig. 2. Photograph of a freshly dead female paratype of *Cirripectes heemstraorum* (54 mm SL, USNM 396714, photographed by Phil Heemstra).

Cirripectes heemstraorum sp. nov.
Common Name: Yellowtail blenny

Holotype. SAIAB 83624, female: 70.6 mm SL, South Africa, KwaZulu-Natal, iSimangaliso Wetland Park, Cape Vidal, 28° 09.660′ S, 32° 33.685′ E, collected on an artificial reef (the DAR 1 barge, sunk on 6 Dec 2008), at 17 m depth, 4 June 2009, Field number PCH09-CV-03, Collectors: Phil and Elaine Heemstra, Guy Musson, Angus W. Paterson, *et al.* (SAIAB tissue number HM09-75).

Paratypes (all collected with the holotype): SAIAB 83881, male: 48.5 mm SL, (SAIAB tissue number HM09-76); and USNM 396714, female: 53.5 mm SL.

DIAGNOSIS. A species of *Cirripectes* with the following combination of characters: nape with greatly expanded black nuchal flap on either side, 10–13 independently based cirri distributed between the nuchal flaps, dorsal fin entire, total supraorbital cirri 5–6, total nasal cirri 6–8, males with small dark spots posteriorly on body coalescing into short black stripes on caudal peduncle, caudal fin of females brilliant yellow (pale in preservative; contrasting sharply with dark brown body), males with outer half of caudal fin brilliant yellow.

consisting of 10, [11], 13 independent cirri distributed between 2 greatly expanded nuchal flaps, each bearing 9, 11, [20] minute cirri on left side and 11, 13, [19] on right side; first dorsal-fin spine of adults approximately equal to second (males and females); dorsal fin entire, not incised above last dorsal-fin spine; dorsal-fin membrane attached to caudal peduncle in advance of base of caudal fin; cephalic pore system simple (1–2 pores at most positions); mid-snout pores present; extra interorbital pore position absent; pore positions behind each nuchal flap 2; male genital papilla with urogenital orifice located basally between 2 widely separated slender filaments (less than 1.0 mm long) on a fleshy swelling behind anus; fleshy anal spine rugosities of male black and arranged in longitudinal rows of uniform fleshy ridges; maximum SL about 71 mm SL.

Colour in alcohol. Male body colouration dark brown with tiny dark blackish brown spots on posterior ½ to ¾ of body with spots posteriorly on body coalescing into short black stripes on caudal peduncle; head brown with pale bar on upper lip on each side, short pale streaks radiate from eye; underside of head with inconspicuous broad brown band across throat; dorsal and anal fins dark brown; anal-fin rugosities black; caudal fin dusky brown over basal half with
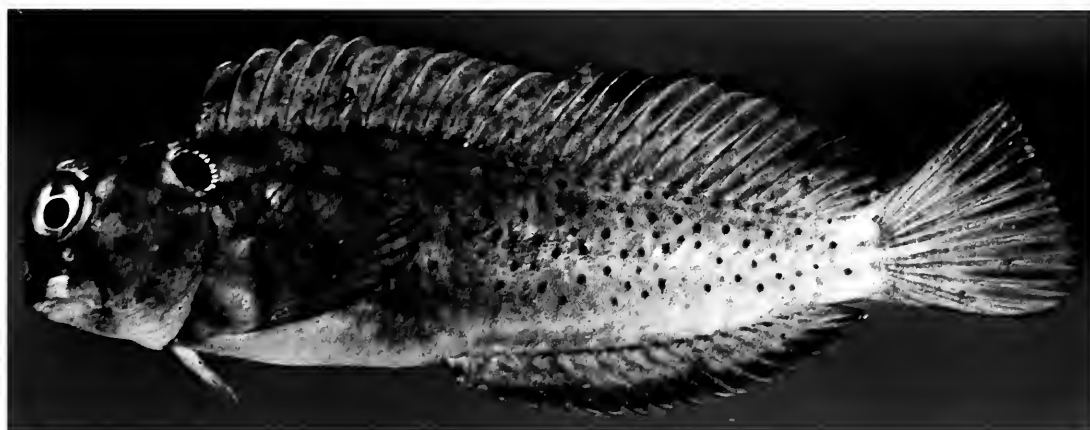
Fig. 3. Photograph of a freshly dead male *Cirripectes auritus* (35 mm SL SAIAB 8888 Sodwana Bay, photographed by Phil Heemstra).

DESCRIPTION (values for each specimen provided where variable, holotype's value in brackets for variable characters). Dorsal-fin rays XII, 16; anal-fin rays II, 17; total procurrent caudal-fin rays 12; caudal-fin rays 13; pelvic-fin rays I, 4; vertebrae 10 + 22 = 32; last pleural ribs on vertebral centrum 11; last epineural on vertebral centrum 15, 16, [17]; anal pterygiophores 1-1-2; total nuchal cirri 30, 34, [51]; supraorbital cirri [5], 6, 6; nasal cirri 6, 7, [8]; LL tubes 4, 10, [14]; last LL tube positioned at point beneath vertical from dorsal-fin ray 4, 10, [16]; no scale-like flaps along LL; lower lip smooth mesially and plicate laterally; gill rakers 21, [22], 25; pseudobranchial filaments on left side 6, 8, [9]; upper lip crenulae approximately 30, 33, [35]; nuchal cirri arrangement

outer half of fin pale; pectoral and pelvic fins brown; nuchal flap black with narrow fringe of pale cirri, the independently based cirri between flaps brown to black; supraorbital and nasal cirri brown.

Females similar to males except spots on caudal peduncle do not coalesce into stripes; caudal fin pale from base to distal margin with fine streak of melanophores along dorsal and ventral margins; no fleshy rugosities on anal spines.

Colour in life (based on colour photos of one male (http://saiab.ac.za/ImageWeb/10418_HM09-076. jpg) and of several female specimens from Cape Vidal, South Africa; Figs. 1, 2): female with head brown and body dark brown, the head with bluish

white spots on snout and around eye, and small reddish brown spots on side of head and anteriorly on body, small scattered spots becoming dark brown to black at mid body and continuing to base of caudal fin; dark brown coloration ending abruptly at caudal-fin base; caudal fin brilliant yellow, contrasting sharply with brown body; dorsal fin dark brown with inconspicuous reddish brown spots on spines and rays and narrow blackish margin; anal fin black with tips of rays grayish blue; pectoral fins yellowish brown; pelvic fins brown; nuchal flap purplish black, bearing tiny yellow cirri, cirri between flaps yellowish brown; supraorbital and nasal cirri pinkish; iris with narrow yellowish inner ring and irregular reddish brown outer ring.

Male similar to female except blackish brown body color extends posteriorly as a rounded dark area covering basal half of caudal fin with posterior half of fin brilliant yellow; rugosities on anal-fin spines bluish black.

DISTRIBUTION. Known only from Cape Vidal, South Africa. The closely related *Cirripectes auritus* (Fig. 3) has been collected 66 km to the north at Sodwana Bay, South Africa, but the two species have not been observed living sympatrically.

COMPARISONS. *Cirripectes heemstraorum, C. auritus* and *C. kuwamurai* Fukao1984, differ from their congeners in having a greatly expanded black nuchal flap with a fringe of minute yellow cirri on either side of the nape and independently based cirri in a row across the nape between the flaps. Although large nuchal flaps are present in members of the *C. fuscoguttatus* group (as diagnosed by Williams 1988), the flaps of species in this group bear well-developed black cirri and the cirri between the nuchal flaps are connected at their bases by a low basal membrane (Williams 1988: Fig. 2). *Cirripectes heemstraorum* and *C. auritus* differ from *C. kuwamurai* (known only from Japan) in having the dorsal fin entire (vs notched over dorsal spine XII); supraorbital cirri 2–7 (vs 12); nasal cirri 4–8 (vs 10); and small dark spots posteriorly on body (vs narrow pale stripes, red in life, on posterior three-fourths of body; Williams 1988: Plate IV, C).

Cirripectes heemstraorum (Figs. 1, 2) differs from *C. auritus* (Fig. 3; and Williams 1988: Plate I, D-G) by having brown pelvic fins (vs pale or dusky); dark brown head and body (vs tan or irregularly barred anteriorly and pale to pinkish posteriorly); females and males having a yellow caudal fin (vs pale, yellowish or pinkish); males with short black stripes on caudal peduncle (vs distinct small spots) and male anal spine rugosities black with uniform rows of fleshy folds (vs pale with irregularly rugose swellings). The single specimen of *C. auritus* known from the Philippines (a 32 mm SL female; USNM 222490) also has a brown body in preservative. The Philippine specimen of *C. auritus* differs from *C. heemstraorum* by its body being a much paler shade of brown and body coloration becoming paler posteriorly as it gradually transitions into a dusky brown caudal fin (vs caudal fin pale and contrasting sharply with dark brown body); and the pelvic fins being dusky (vs brown).

ETYMOLOGY. The new species is named in honor of Phil and Elaine Heemstra, in recognition of their contributions to our knowledge of marine fishes, particularly from South Africa, who collected all of the known specimens of the new species and provided a color photograph showing the life colors (Fig. 2).

REMARKS. Elaine Heemstra provided the following information on environmental conditions at the type locality.

"… The Cape Vidal *Cirripectes* were found on a new artificial reef — 2 barges that were sunk at the end of last year. The shallower of the 2 barges, DAR 1, where the *Cirripectes* were collected, was sunk on the 16th December 2008. Its bow deck is at about 17 m deep and the barge gets shallower towards the stern; the substrate upon which the barge sits is about 26 m. DAR 2 at 27–30 m (substrate ~ 42 m) was scuttled the month before. Benthic growth on both decks is predominantly barnacles (*Balanus* spp.) and a covering of loosely attached "pearl oyster" type bivalves that are still to be identified. The benthic cover is denser on DAR 1 than DAR 2 and very few soft corals are present at this stage. The barges are on a sandy area that is exposed to fairly constant currents of 3–4 knots & the water was about 22–23° C [in early winter]. There was little or no current only about every 4th day that we were there. At Cape Vidal there is some shallow, patchy reef along the shoreline but only one offshore reef, known as Oscar's Reef, at ~35 m. The barges are isolated from other reefs, the closest, Oscar's Reef, being about 6 km north of the area."

The distinctive yellowtail blenny has not been observed previously by divers in the area (E. Heemstra pers. comm.) and the natural source population of the DAR 1 adult colonizers remains unknown. Potential areas to search for other populations of the yellowtail blenny would be high energy wave swept shores or reefs prone to dangerous fast currents where divers typically do not frequent.

DNA barcode sequences for the cytochrome c oxidase subunit1 gene (CO1) were obtained from tissue samples taken from the female holotype (SAIAB 83624, tube number HM09-75) and the male paratype (SAIAB 83881, tube number HM09-76). The CO1 sequences have been deposited in GenBank as accession numbers: GU357568 for SAIAB 83624; GU57569 for SAIAB 83881

COMPARATIVE MATERIAL EXAMINED. A total of 11 specimens of *C. auritus*, 28-71 mm SL, were examined. SOUTH AFRICA: SAIAB 8888, 38 mm; SAIAB 9547, 48 mm. Type material: BPBM 20478, 1: 71 mm, holotype, Line Islands, Fanning Island. Paratypes: ANSP 138366, 2: 43-48 mm, Line Islands, Fanning Island; CAS 34383, 2, Grand Comoro Island;

CAS 48948, 28 mm, Line Islands, Christmas Island; USNM 22489, 2: 50-55 mm, Line Islands, Fanning Island; USNM 222490, 32 mm, Philippines, Apo Island.

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Revision of the ariid catfish genus *Galeichthys* Valenciennes (subfamily Galeichthyinae), with description of a new species from South Africa and designation of a neotype for *G. ater* Castelnau

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ABSTRACT. The ariid catfish genus *Galeichthys* Valenciennes is re-diagnosed and four species are recognised. Among ariids, *Galeichthys* is most readily distinguished by a long and narrow supraoccipital process that is easily detected through the skin. A neotype is designated for *G. ater* and one new species is described. *Galeichthys trowi* sp. nov. is distinguished externally by colouration, length of the dorsal and pectoral fin spines, and adipose fin shape. Notes on sexual dimorphism and osteological features that contribute to specific identity of the four species are included in the descriptions and diagnoses. Synonymies, a brief nomenclatural history, and a key to the species of *Galeichthys* are provided.

RÉSUMÉ. L'espèce poisson chat du genre *Galeichthys* Valenciennes (Ariidae) est diagnostiquée et quatre autres espèces sont aussi diagnostiquées. Parmi ces espèces Ariidae, *Galeichthys* est le plus facilement distinctif par une longue et étroite forme occipitale que l'on découvre facilement à travers la peau. Un nouveau type est désigné sous *G. ater* et une autre nouvelle espèce est décrite. *Galeichthys trowi* sp. nov. se distingue extérieurement par sa couleur, sa longueur des épines dorsales et pectorales et sa forme fine et adipeuse. Les notes sur son dimorphisme sexuel et ses traits ostéologiques contribuent à l'identification spécifique des quatre espèces dont les diagnostiques et les descriptions sont incluses. Une brève nomenclature historique et une clé d'identification des espèces *Galeichthys* sont disponibles.

INTRODUCTION

Species of the genus *Galeichthys* Valenciennes in Cuvier & Valenciennes (1840) are medium-sized ariid catfishes occurring in coastal and estuarine waters of southern Africa (three species) and in coastal waters of Peru (one species). All species of *Galeichthys* are male-mouthbrooders of eggs and embryos (Tilney & Hecht, 1993; this work), which is a diagnostic character of the family Ariidae (Rimmer & Merrick, 1983; Kailola, 2004; Acero & Betancur-R., 2007). *Galeichthys* species are common fishes in their respective ranges, having some (largely unquantified) commercial value, since they are taken as a by-catch with a variety of gear in commercial and artisanal fisheries. Ariids are phenotypically similar fishes and their character-states tend to be conservative, leading to difficulty for taxonomists (Kailola, 1991). Thus, the genus *Galeichthys* constitutes a group of morphologically similar species within a family of morphologically similar fishes. At times in its nomenclatural history, *Galeichthys* has been variously extracted from and included in the speciose type genus *Arius* Valenciennes (1840) which, as recognised at present, certainly remains

paraphyletic (Taylor, 1987; Burgess, 1989; Kailola, 1991 and 2004). The valid genus *Galeichthys* has also been referred to as *Tachysurus* Lacepède, which is considered a *nomen dubium* and an invalid genus (Wheeler & Baddokwaya, 1981).

Since studies on the biology and ecology of the type species *G. feliceps* Valenciennes during the 1980s, an undescribed species of *Galeichthys* from the east coast of South Africa has been recognised (see Tilney & Hecht, 1990; Branch et al., 1994; Smale, Watson & Hecht, 1995; King, 1997; P. C. Heemstra, pers. comm.). Differences in morphology, osteology and habitat between the two forms are consistent with an uncommon geographic range. This new species is described from 50 specimens collected from coastal areas of KwaZulu-Natal Province and the Transkei region of the Eastern Cape Province.

Acero & Betancur-R. (2007) have recently described the new subfamily Galeichthyinae, comprising the genus and four species described here, distinguished by one derived morphological state (consisting of the fan-shaped lamina of the postcleithral process); the subfamily Ariinae then includes the remaining ariids.

MATERIALS AND METHODS

Species descriptions are based on the following material: *G. ater* − 31 specimens (130–320 mm SL) measured and examined, 2 skeletonised, 2 cleared and stained for bone and cartilage, 4 radiographed (inclusive of the neotype); *G. feliceps* − 31 specimens (140–330 mm SL) measured and examined, 4 skeletonised, 2 cleared and stained for bone and cartilage, 4 radiographed; *G. trowi* sp. nov. − 50 specimens (225–480 mm SL) measured and examined, 5 skeletonised, 4 radiographed (paratypes); *G. peruvianus* − 15 specimens (86–345 mm SL) measured and examined, 2 skeletonised, and 1 skull only (CAS 47043), 2 radiographed, and radiographs of the 2 syntypes.

Methods for counts and measurements follow Hubbs & Lagler (1964), with the following additions: dorsal fin spine length is measured from the base (posterior of the first, rudimentary spine) to the distal bony tip, pectoral fin spine length from the base to the distal bony tip with fin adpressed to the body, and the relative length of the maxillary barbel in relation to the pectoral fin was approximated with the fin extended. Standard length was obtained using a mm-graduated ruler; other body measurements were made as straight-line distances with dial calipers to the nearest 0.5 mm, and are expressed as a percentage of standard length or head length. Vertebral counts are taken from skeletonized specimens and radiographs of some type material: total vertebral count includes the five vertebrae involved in the anterior complex centrum, and the compound preural-ural centrum is counted as one element. Anal fin ray counts were made from radiographs. Dry skeletons were prepared and the swimbladder and the utricular otoliths of several individuals of each species were removed for examination. Sex was determined by examining the gonads, or, in the case of a few large individuals (after gonads had been removed), by shape of the posterior (humeral) process of the cleithrum. Intra-specific skeletal differences and sexually dimorphic features are included in the diagnoses and descriptions.

Institutional abbreviations are as listed in Leviton *et al.* (1985); I add DIFS for the Department of Ichthyology and Fisheries Sciences, Rhodes University, Grahamstown, South Africa. Abbreviations used in the text are: A – anal fin, C – caudal fin, D – dorsal fin, FL – fork length, GR – gill-rakers, HL – head length, P – pectoral fin, SD – standard deviation, SL – standard length, and V – ventral fin.

Table 1. Proportional measurements of specimens of *Galeichthys* as percentages of the head length (HL) and standard length (SL); significant differences ($p \leq 0.05$) are marked by an asterisk (SD = standard deviation).

	G. ater (n = 31)			G. feliceps (n = 31)		G. peruvianus (n = 15)	
	neotype	range	SD	range	SD	range	SD
SL (mm)	190	130–320	35.3	140–330	45.4	86–345	63
Percent HL:							
Head width	98	85–103	4.0	48–106	9.3	68–87	15.6
Snout length	37	31–48	3.0	31–50	3.4	22–38	15.1
Mouth width	51	46–57	2.8	39–62.5	4.5	36.5–45	26.4
Posterior-nostril to eye	12.5	8.5–40	4.6	11–44	5.6	9.5–34	54.3
Inter-anterior nostril width	31	27–32	1.3	23–45	4.1	19–29	21.0
Interorbital width	55	45–57	2.9	41–66	4.3	46–52	22.5
Eye diameter	18	13–20	1.4	12–22	2.1	13–34	49.1
Maxillary barbel length	86	63–89	6.8	41.5–112.5	13.2	56.5–91	19.0
Percent SL:							
Predorsal length	36	10–40	5.1	9.5–39	4.9	34–40	1.7
Body depth	26	20–27	1.9	17–26	1.8	17–22	14.3
Head length	26	23–31	1.6	20–37	2.6	25.5–31	16.1
Head width	25	22–29	1.5	13–26	2.0	19–23	10.8
Dorsal fin base	9	8.5–11	0.7	8–10	0.6	7–11	9.4
Dorsal spine length	16	13–22.5	1.9	15–21	1.3	14–18	11.1
Pectoral fin base	6	5–7	0.4	4.5–6	0.4	4–7	7.7
Pectoral spine length	19	15–24	2.2	17–24.5	1.8	15–20	15.8
Adipose fin base	11	9–13	1.0	7.5–13.5	1.2	6.5–14	17.8
Adipose fin height	6	4.5–8.5	0.8	4–6.5	0.7	3–6	5.9
Caudal peduncle depth	9	7–14	1.1	6.5–9	0.5	6–11	11.4
Caudal peduncle length	16	13–24.5	2.0	12–22	1.7	15–23	21.7
Upper caudal lobe length	26	18–28.5	1.8	23–30.5	1.9	20.5–29	23.8
Lower caudal lobe length	23	17–25	1.9	20–28	1.6	16–26	22.0

Genus *Galeichthys* Valenciennes

Galeichthys Valenciennes, in Cuvier & Valenciennes, 1840: 21, pl. 424. Type species *Galeichthys feliceps* Valenciennes 1840, by subsequent designation of Bleeker, 1862: 7; Bleeker, 1863: 90; Günther, 1864: 174; Jordan & Evermann, 1896: 119; Boulenger, 1909: 381; Meek & Hildebrand, 1923: 104; Hildebrand, 1946: 119, 123; Taylor, 1986a: 212; Acero & Betancur-R., 2007: 139 (new subfamily).

Bagrus, in part., Müller & Troschel, 1849: 6, as *Bagrus bagrus feliceps*.

"*Tachysurus*" Lacepède, 1803: 150, 151. Type species *Tachysurus sinensis* Lacepède (a Latinization of *Tachysure chinois*), by monotypy, from a Chinese painting of a siluroid-like fish, but not identifiable to family; Eigenmann & Eigenmann, 1890: 41 (spelled *Tachisurus*); Jordan & Evermann, 1896: 121; Smith, 1962: 39; Tilak, 1965: 150; Jayaram, 1981: 278.

Diagnosis. A genus of fork-tailed catfishes distinguished by the following six characters unique to *Galeichthys* within the Ariidae: 1) externally smooth head at all growth stadia (the striate and rugose head shield covered by skin and muscle); 2) supraoccipital process long and narrow, sides nearly parallel (easily detected through the skin); 3) epioccipital lamellae weakly developed, posteriorly projecting but remote and not contacting expanded parapophyses of vertebrae four and five; 4) one 'free' supraneural exposed in dorsal surface between supraoccipital and predorsal plate; 5) Müllerian ramus of vertebra four inflexible and attached midway to posterior facet of ossified Baudelot's ligament of postemporo-supracleithrum (elastic spring mechanism absent); and 6) posterior (humeral) process of the cleithrum forming fan-shaped lamina, with posteroventral margin broadly rounded in females and more triangular or angular in males.

Key to Species of *Galeichthys*

Proportional measurements for the nominal species are presented in Table 1, and those for the new species in Table 2.

1a.   Caudal fin lobes rounded; caudal peduncle short and thick (depth > half peduncle length); both belly and underside of head anterior to isthmus densely covered with fine brown specks ....*Galeichthys ater*

1b.   Caudal fin lobes pointed; caudal peduncle somewhat slender (depth < half peduncle length); belly white, pearly, cream, tan to yellowish; speckled only laterally, or with fine brown specks on belly posterior to isthmus only (underside of head without specks)... 2

2a.   Head with narrow and shallow dorsomedian groove; palatal tooth patches separated at midline; silvery lateral stripe and belly cream-coloured; maxillary barbels not reaching pectoral fin spine origin; anterior nostrils ovate; swimbladder heart-shaped but with angular antero-lateral margins, longitudinal septum of posterior chamber traversed by one small septum .... *G. peruvianus*

2b.   Head without dorsomedian groove; palatal tooth patches slightly separated, touching or united at midline; maxillary barbels extending at least to pectoral fin spine origin; anterior nostrils rounded; swimbladder heart-shaped and anterior margins well rounded 3

3a.   Belly white, sometimes off-white (speckles of violet-brown pigment present laterally, but never mid-ventrally); dorsal fin spine at least 70% of fin height; pectoral fin spine reaching at vertical to, or less than, hind edge of dorsal fin base; free posterior rim of adipose fin relatively short (about equal to one-third length of adipose base); longitudinal septum of posterior chamber of swimbladder without small transverse septum; marine or estuarine habitat .... *G. feliceps*

3b.   Belly pale brown, off-white to yellowish and densely covered by fine brown specks (posterior to isthmus only); dorsal fin spine less than 70% of dorsal fin height; pectoral fin spine reaching at vertical to slightly beyond hind edge of dorsal fin base; free posterior rim of adipose fin relatively large (equal to approximately half length of adipose base); longitudinal septum of posterior chamber of swimbladder divided by one small transverse septum; strictly marine .... *G. trowi* sp. nov.

Galeichthys ater Castelnau, 1861
Figs. 1, 2 & 7; Table 1

Galeichthys ater Castelnau, 1861: 62 ("mers du Cap": Cape of Good Hope, South Africa). Boulenger, 1911: 382, fig. 296; Gilchrist, 1914: 104 and 1916: 2, 18 (early development); Buxton *et al.*, 1984: 184 (trawl survey); Taylor, 1986a: 212, fig. 59.2 (description, illustration); Hecht & Tilney, 1989: 103 (fishery); Smale & Buxton, 1989: 58 (subtidal community); Tilney & Hecht, 1990: 171, 5 figs. (feeding habits and morphology); M. Wilhelm,

1999, cited in Mann, 2000: 6 (management report); Acero & Betancur-R., 2007: 135, 136, 139, 140, 5 figs. (cranium and cleithrum).

Galeichthys feliceps (non Valenciennes): Barnard, 1925: 160 (in part).

Arius ater: Burgess, 1989: 168.

Neotype. RUSI 63803; 190 mm SL (male), Indian Ocean at Tsitsikamma Coastal Marine Park, Eastern Cape Province, South Africa; collected by R. Tilney and J. Davis, 30 November 1993.

Fig. 1. *Galeichthys ater* Castelnau, neotype, 190 mm SL, male, SAIAB 63803.

To preserve nomenclatural stability, a neotype is selected for *G. ater*, since no known types exist. Castelnau (1861) described *G. ater* from two specimens collected from Table Bay (Cape Town, South Africa) wherein, although it is less frequent than *G. feliceps*, he erroneously attributed it as 'very rare.' The species is comparatively abundant in the locality where the neotype was collected. The condition of the neotype is very good; the belly is slit longitudinally.

DIAGNOSIS. Head short, nearly as broad as long. Snout blunt, well-rounded in lateral profile and dorsally. Palatal tooth patches posterior to

premaxillary tooth band meet at midline. Caudal-fin lobes rounded, of near equal length, fin not deeply forked; caudal peduncle short and thick. Underside of body (both head and belly) covered with fine brown specks. Anterior gill-rakers on first arch 10–13 (5 + 5). Pectoral fin rays 9–12 (11); fatty growth along pectoral fin spines of breeding females not present outside spawning season. Dimorphism of posterior (humeral) process of cleithrum obvious externally: fan-shaped in females, triangular in males. Dorsomedian cranial depression on exposed skull smooth, shallow, and posteriorly does not reach supraoccipital process.

DISTRIBUTION. Strictly marine and common along the entire south coast of South Africa, from Table Bay, Cape Town (Atlantic Ocean) to the vicinity of East London (Indian Ocean). Less commonly known north of this range, but recorded from the west coast to Walvis Bay, Swakopmund, Namibia (Tilney & Hecht, 1990; RUSI uncatalogued, 3 specimens: skiboat catch of R. Maasden, 1987, re-examined here), and on the east coast to Margate, KwaZulu-Natal Province, South Africa, the northeastern-most record for the species (RUSI 56501, 2).

COMPARISONS. In the field, *G. ater* is easily distinguished from the sympatric *G. feliceps*, which has a stark white belly and pointed caudal lobes, and from *G. trowi* sp. nov. which has pointed caudal lobes and no speckling on the underside of the head, but only on the belly. The dentition is similar to *G. feliceps* (see Tilney, 1990, plate II), except that the tooth bands are slightly broader in *G. ater* than in *G. feliceps* (Tilney & Hecht, 1990).
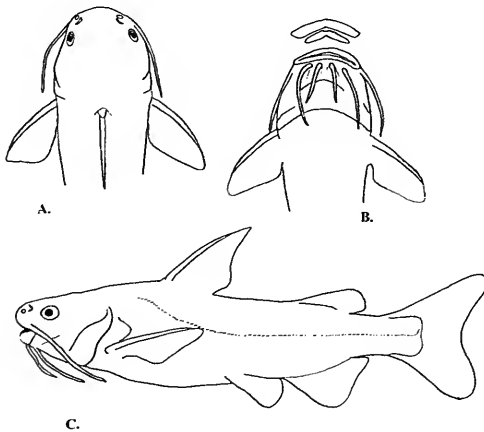

Fig. 2. *Galeichthys ater* Castelnau, neotype: line drawing of A) dorsal view of head; B) ventral view of head and belly, and schematic drawing of premaxillary and palatal tooth patch arrangement; and C) lateral view.

Galeichthys feliceps Valenciennes, 1840
Figs. 5–7; Table 1

Galeichthys feliceps Valenciennes, in Cuvier & Valenciennes, 1840: 29, pl. 424 ("environs du Cap": Cape of Good Hope, South Africa). Syntypes mounted (5), MNHN A.9361–A.9365 [not examined]; Castelnau, 1861: 62; Günther, 1864: 175; Weber, 1897: 186, 191; Boulenger, 1891: 148 (eggs); Boulenger, 1911: 381, fig. 295; Gilchrist, 1914: 104; Gilchrist, 1916: 2, 18; Barnard, 1925: 160; Poll, 1953: 166, 258, fig. 67; Taylor & Van Dyke, 1981, fig. (FAO species identification sheets); Buxton *et al.*, 1984: 158 (trawl survey); Coetzee & Pool, 1985: 33 (diet); Rucabado, 1986: 227; Taylor, 1986a: 213 (description, illustration); Bennett, 1989: 164 (diet); Hecht & Tilney, 1989: 103 (fishery); Taylor, 1990: 233 (checklist); Tilney & Hecht, 1990: 171, 5 figs. (feeding habits and morphology); Marais & Venter, 1991: 149 (body composition); Tilney & Hecht, 1993: 183 (ontogeny); Whitfield et al., 1994: 182, fig. 9 (estuarine survey); Whitfield, 1998: 63; R. L. Tilney, 1999, cited in Mann, 2000: 8 (management report); Marceniuk & Menezes, 2007: 61, 62, 2 figs.
Pimelodes fossor Lichtenstein, 1823: 112 (*nomen dubium*; Cape of Good Hope, South Africa). Holotype lost; based on a specimen of *Galeichthys* but the description does not clearly distinguish between the two southern African species (*G. ater* and *G. feliceps*) (Taylor, 1986b); Peters, 1868: 455, in synonymy of *G. feliceps*; Ferraris, 2007: 431 (type catalogue; *species inquirenda* in Siluriformes); Kailola, 2004: 127, 136, and Marceniuk & Menezes, 2007: 63, in possible synonymy of *G. feliceps*.
Bagrus capensis Smith, 1838–47 [1840]: pl. 8 (Cape of Good Hope, South Africa). Holotype (dry mount), BMNH 1857.6.13.147 [not examined]; Pappe, 1853: 29; Smith, 1838–47: pl. 8; Taylor, 1986b: 158; Taylor, 1990: 234; Kailola, 2004: 136; Ferraris, 2007: 43 (type catalogue); Marceniuk & Menezes, 2007: 63.
Pimelodus peronii Valenciennes, in Cuvier & Valenciennes, 1840: 161 (Indian Ocean). Holotype (unique): MNHN 0000-1207. Bertin & Estève, 1950: 13 (type catalogue); Kailola, 2004: 136, and Ferraris, 2007: 43, in synonymy of *G. feliceps*.
Bagrus bagrus feliceps: Müller & Troschel, 1849: 6.
Ariodes polystaphylodon: Fermor, 1913: 196, 3 figs. (skull).
Galeichthys ocellatus Gilchrist & Thompson, 1916: 60, fig. (Swartkops River, Algoa Bay, South Africa). Holotype, RUSI 60956, 140 mm SL; Thompson, 1916: 74; Barnard, 1925: 161.
Tachysurus feliceps: Fowler, 1936: 330, 333; Smith, 1949: 109, fig. 165; Smith, 1975: 20; Hecht & Hecht, 1978: fig. 6 (otolith); Marais, 1981: 144 (estuarine survey); Marais & Baird, 1980: 68 (estuarine survey); Hecht & Hecht, 1981: 404, fig. 4–6 (otoliths); Marais, 1983: 96 (seasonal abundance); Marais, 1984: 210 (estuarine feeding ecology).
Tachysurus fossor (? non *Pimelodes fossor* Lichtenstein, 1823): Smith, 1962: 39; Smith & Smith, 1966: 36, fig.
Arius feliceps: Van der Elst, 1981: 342, fig.

Type material. *G. feliceps* was well-described by Valenciennes from an unspecified number of specimens taken from Table Bay (Cape Town, South Africa), but he did not designate type material. Five dry-mounted syntypes were subsequently chosen by Bleeker (1862) when he designated *G. feliceps* as the type species of *Galeichthys*. The syntypes are deposited in the MNHN; although these were not re-examined for this study, the species as described here can be confidently matched to the original descriptions by Valenciennes and Bleeker. The collection locality given in those early descriptions matches the known range of the species and is outside of the range of the new species from the Eastern Cape and KwaZulu-Natal provinces (and formerly identified as *G. feliceps*). The lost holotype of *G. ocellatus* has been relocated and is catalogued as RUSI 60956.

DIAGNOSIS. Head longer than, or nearly as long as, broad. Tooth patches posterior to premaxillary band touch at midline. Maxillary barbel relatively long, thin, and extending at least to pectoral fin spine origin (longer in females). Dorsal fin spine length more than 70% of dorsal fin height. Pectoral-fin spine at vertical extends at most to hind edge of dorsal fin base. Caudal fin deeply forked, with moderately slender, pointed lobes, upper lobe longer; caudal peduncle approximately twice as long as deep. Gill-rakers on anterior face of first arch 11–14. Upper two-thirds of body darkened, some lateral speckling and belly stark white. Median anterior cranial fontanelle (of exposed skull) elongate and bullet-shaped; median cranial depression smooth, shallow, and deepest posteriorly at frontal/supraoccipital suture. Pectoral fin rays 10–12. Dimorphism of posterior (humeral) process of cleithrum obvious externally: fan-shaped in females, triangular in males. Total vertebrae 51–52 (17 precaudal, 34–35 caudal).

DISTRIBUTION. From Walvis Bay, Namibia to the vicinity of East London, South Africa; especially abundant along the entire southern coast, from Cape Town to Port Alfred. North-easterly limit: Mbashe River mouth (32°S, 28°E), known from numerous estuarine surveys north of the Kei River Mouth (Plumstead, 1984; Plumstead et al., 1985 and 1989; Branch & Grindley, 1979). Thus, there is probably little or no distributional overlap with the entirely marine *G. trowi* sp. nov.

COMPARISONS. See comments for *G. ater*, above. More is known of the biology and ecology of *G. feliceps* than of any other species of the genus. *G. feliceps* is the only *Galeichthys* species occurring in both marine and estuarine habitats.

Galeichthys peruvianus Lütken, 1875
Fig. 7; Table 1

Galeichthys peruvianus Lütken, 1875: 205 in Vol. I for 1874 (Callao, Peru). Syntypes (2), ZMUC 150 and 490. Steindachner, 1875: 34 (Callao, Peru; Panama Bay; and Altata, Mexico); Jordan & Evermann, 1896: 122; Gilbert & Starks, 1904: 21; Regan, 1908: 125; Evermann & Radcliffe, 1917: 31, pl. 4; Nichols & Murphy, 1922: 506; Meek & Hildebrand, 1923: 105; Tortonese, 1939: 230; Hildebrand, 1946: 123; Chirichigno, 1974: 129, fig. 145; Kailola & Bussing, 1995: 882, fig; Acero & Betancur-R., 2007: 139 (molecular data).

Tachisurus peruvianus: Eigenmann & Eigenmann, 1888: 140, fig. 7 (teeth), and 1890: 51 (Callao, Peru).

Type material. The existing type series for *G. peruvianus* consists of the two syntypes (270 mm and 260 mm SL) deposited with the ZMUC. Both are alcohol preserved and in good condition, but that the dorsal and pectoral fins are cut off just above the base in each (J. Nielsen, ZMUC, pers. comm.); radiographs of those specimens were examined for this study. The publication date of the original description has often been given as 1874; in such cases the year should be amended to 1875.

DIAGNOSIS. Head and body slender; body posteriorly well tapered. Caudal fin lobes pointed, upper lobe longer; caudal peduncle long and narrow. Lateral body with silvery to reddish stripe. Tooth patches posterior to premaxillary tooth band slightly separated at midline. Anterior gillrakers on first arch 13–15. External skull with shallow, narrow dorsomedian groove, extending from interorbital area to base of supraoccipital. Cranial fontanelles (of exposed skull) set within steeply-welled median cranial depression, or fissure, with nearly parallel sides. Skull rugose, striate and tuberculate in part. Swimbladder angularly heart-shaped and anterior margins more triangular than rounded; longitudinal septum of posterior chamber of swimbladder traversed by one smaller septum. Aortic canal on ventral side of Weberian apparatus uncovered by lamellae (no aortic tunnel formed). Müllerian ramus of fourth vertebra with irregularly textured, ovoid, concave facet on ventral side. Posterior (humeral) process of the cleithrum broad, blade-like.

DISTRIBUTION. Coastal marine; not known to enter estuaries. Currently known as abundant only from the coast of northern Peru (Taylor, 1986a; Kailola & Bussing, 1995), with frequent catches historically recorded from the Bay of Callao (Lima). Several early descriptions have attributed this species' distribution to include a more northerly range, e.g., "Pacific coast of Mexico to Peru, rather rare," in Jordan & Evermann, 1896; "Altata, Mexico, Panama to Callao, Peru," in Meek & Hildebrand, 1923. However, such distributional records are more likely based on hearsay rather than reports of actual capture localities, or they may be misidentifications

with *Arius* species, particularly, *"Arius" seemanni* Günther [= *Arius jordani* Jordan & Evermann], which it superficially resembles.

COMPARISONS. *G. peruvianus* is a smaller-sized, narrow-bodied species of *Galeichthys*. It is well distinguished from other co-occurring ariids by its long, slender supraoccipital process (which can be detected through the skin), and from other *Galeichthys* species by the silvery lateral stripe, palatal tooth patches invariably separated at the midline, shallow dorsomedian head groove, and, on the exposed cranium, the steep-walled cranial depression (within which the cranial fontanelles are set). The sexual dimorphism of the humeral process of the cleithrum (but less pronounced than that found in *G. ater* and *G. feliceps*) and the configuration of the small transverse septum of the posterior chamber of the swimbladder (resulting in two pairs of bipartite posterior chambers) resembles that of the new species, *G. trowi*. Kailola (1991) proposed that an open aortic canal (here, unique to *G. peruvianus* within the genus) represents the primitive condition in catfishes (cf. partially covered canal in *G. ater* and *G. feliceps*, and the aortic tunnel being most extensive in *G. trowi*).

Galeichthys trowi sp. nov.
Figs. 3–6; Table 2

Galeichthys feliceps: Taylor, 1986a: 213 (in part); Taylor, 1986b: 158 (in part) (checklist).
Galeichthys sp.: Branch et al., 1994: 224, pl. 105.1; King, 1997: 18, pl.; Smale et al., 1995: 24, pl. 8 (otolith); Beckley & Fennessy, 1996: 191 (fishery).

Holotype. SAIAB 60957, male, 435 mm SL, Coffee Bay (31°59'14" S, 29°09'14" E), Eastern Cape Province, Indian Ocean, South Africa, trawl at 31-m depth, 6 Nov. 1994, collected by Eugene Trow Sr.

Paratypes. SAIAB 45967, male, 350 mm SL, KwaZulu-Natal Province, Jan. 1994, collected by P.C. Heemstra; SAIAB 60958, male, 435 mm SL, same data as holotype; SAIAB 60959, female, 450 mm SL, same data as holotype; SAIAB 63227, male: dry skeleton, 355 mm SL, Coffee Bay, Eastern Cape Province, Oct. 1993, collected by Tom Hecht/DIFS; AMNH 250602; 440 mm FL; Transkei coastline, Eastern Cape Province, 1985, collected by E. Trow Sr.; AMS I.45270-001; 145 mm TL; Coffee Bay, Transkei coastline, Eastern Cape Province, 1984, collected by E. Trow Sr.; BMNH 2010.4.19.347, 420 mm FL, Transkei coastline, Eastern Cape Province, 1985, collected by E. Trow Sr.; CAS 229110, 450 mm FL, Transkei coastline, Eastern Cape Province, 1985, collected by E. Trow Sr.; MZUSP 104605, 420 mm SL, Coffee Bay, Transkei coastline, Eastern Cape Province, 1984, collected by E. Trow Sr.; USNM 396993, 440 mm SL, Transkei coastline, Eastern Cape Province, 1985, collected by E. Trow Sr.
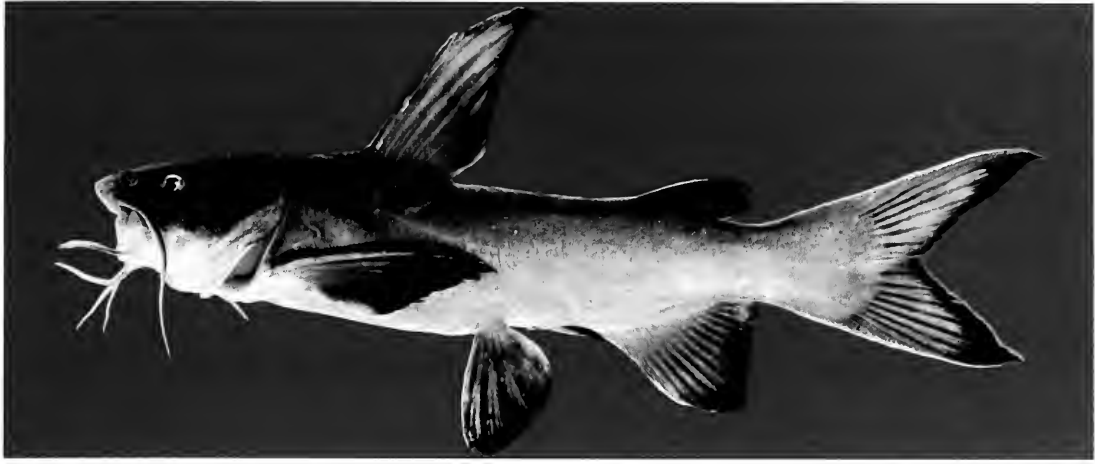
Fig. 3. *Galeichthys trowi*, paratype, 145 mm SL, juvenile male, SAIAB 45967, Anchor Reef, KwaZulu-Natal, photographed by Phil Heemstra.

Additional material. RUSI 40640 (2), males, 314 and 322 mm SL, KwaZulu-Natal Province, Park Rynie, Landers reef, 4 km offshore, 5 Aug. 1992, collected by C. Buxton, P.C. Heemstra and others; RUSI 43345 (11), 225–435 mm SL, Scottburgh (KwaZulu-Natal Province) to Port Edward (Eastern Cape Province), from shore, 2–3 Oct. 1993, collected by Rudy Van der Elst for the Oceanographic Research Institute (ORI), Durban; RUSI 63684 (3), 390–410 mm SL, Transkei coastline, Eastern Cape Province, 1983, collected by E. Trow Sr.; RUSI 63685 (3), 395–445 mm SL, Coffee Bay, Transkei coastline, Eastern Cape Province, 1984, collected by E. Trow Sr.; RUSI 63686 (6), 305–450 mm SL, Transkei coastline, Eastern Cape Province, 1985, collected by E. Trow Sr.; RUSI 63687 (7), 335–470 mm SL, same data as holotype.

Type material. Condition of the holotype is good, but that the body is slightly curved and the barbels somewhat dehydrated and stiff; the belly is longitudinally slit on the left side, as the stomach, intestines and gonads had been removed shortly after collection. The dry skeletal paratype is nearly complete except for the anal fin, left pectoral fin rays, and pleural ribs. The small juvenile specimen is in excellent condition. Other paratypes are in similar condition to the holotype, but some specimens have flesh removed from over the hypural plate, left side, and some have guts and gonads intact.

DIAGNOSIS. Total vertebrae 55–57 (19–21 precaudal, 36 caudal) and 15 pleural ribs attached to parapophyses of vertebrae 6 through 20; pectoral fin rays I, 12–13; anal fin rays 19–20. Eyes small, ovate; dorsolaterally placed. Vomerine tooth patches slightly separated at midline, continuous with lateral patches that taper at edges. Premaxilla plates with pointed anterolateral corners. Gill-rakers on anterior face of first arch 12–13. Anterior dorsomedian cranial fontanelle constricted midway, approximating elongate hourglass-shape;

remnant posterior fontanelle relatively large. Dorsal fin spine approximately two-thirds length of dorsal fin height (= longest dorsal ray). Pectoral fin spine extending slightly beyond dorsal fin base at vertical; humeral process of cleithrum with second, smaller blunt process on border between blade and prong. Adipose fin moderately large, with free posterior rim about half into length of adipose-fin base, and darker in colour than upper body. Fourth neural spine with thin anterior laminar keel and moderately elevated forward ridge extending to third neural spine; Müllerian ramus of fourth vertebra with acute transverse edge on ventral side. Pterotic with diminutive antrorse, pterotic spine. Lateral line with short, oblique venules emanating both upward and downward along its length. Swimbladder heart-shaped and anterior margins rounded; the longitudinal septum of the posterior chamber traversed by one small septum. Dorsal and lateral body colour (in life and alcohol) medium brown to deep brown; underside paler or yellowish, belly pigmented by fine brown specks posterior to isthmus only; fins blackish; barbels brown.

DESCRIPTION. Based on 50 specimens, inclusive of the holotype, paratypes and additional material.

A large, robust species of *Galeichthys*, commonly attaining over 40 cm FL. Head broad, moderately long. Head shield smooth externally. Greatest body depth just anterior to dorsal fin spine origin. Predorsal profile gently sloping to straight; interorbital region flat. Eyes ovate, relatively small at all stadia. Snout somewhat flat, broad, and rounded to slightly squarish. Mouth wide, nearly straight, subterminal to slightly inferior; lips equally thick and fleshy at front of jaws and sides of mouth, upper lip thickest and crenulate (especially in larger fish). Nostrils rounded; anterior nostrils positioned just slightly lateral to posterior ones; posterior nostrils covered by a flap. Gill openings wide, membranes

Table 2. Proportional measurements of specimens of *Galeichthys trowi* sp. nov. as percentages of the head length (HL) and standard length (SL), and meristic data for the type specimens (*n* = sample size; SD = standard deviation).

Character	Holotype	All specimens			
		n	Mean	Range	SD
SL (mm)	435	50	384	225–480	
Percent of HL:					
Head width	88	50	86.3	79–95	3.8
Snout length	38	50	38.9	36–44	1.6
Mouth width	50	50	47.9	41–59	3.3
Inter-anterior nostril width	28	50	27.7	25–34	1.4
Interorbital width	51	50	46.9	42–52	2.3
Eye diameter	13	50	12.9	11–15.5	0.9
Maxillary barbell length	59	50	66.2	55–80	5.0
Percent of SL:					
Predorsal length	37	50	37.3	35–55	2.8
Head length	29	50	28.6	26–42	2.1
Head width	26	50	24.7	22–36	1.9
Body depth	24	50	23.0	19–32	1.9
Dorsal-fin base	9	50	10.2	8.5–14	0.9
Dorsal spine length	18	46	18.3	16–28	1.8
Pectoral-fin base	6	50	5.9	5–9	0.6
Pectoral spine length	22	50	21.8	19–35	2.3
Adipose base	9	49	8.8	6–11.5	1.1
Adipose height	5	49	4.9	3.5–8	0.7
Caudal peduncle depth	9	50	8.7	8–12	0.7
Caudal peduncle length	13	50	14.8	12.5–20	1.3
Upper caudal lobe length	25	45	26.1	20–42	3.2
Lower caudal lobe length	24	49	23.6	19–37	2.7
Counts	**Holotype**	**Paratypes**			
Gillrakers (anterior, 1st arch, right side)	6+7	6+7 (*n* = 6)			
Anal fin rays	20	Range: 19–20 (*n* = 4)			
Pectoral fin rays	13	Range: 12–13 (*n* = 6)			
Total vertebrae	57	Range: 55–57 (*n* = 4)			

meeting well forward at 90-degree angle, attached to isthmus, and with short, free posterior margin.

Premaxillary and palatal tooth patches of equal length and divided by (broad) velum approximately equal to width of premaxillary tooth patch. Barbels thin and tapered; maxillary barbel longest and reaching origin of pectoral fin spine. Dorsal fin base relatively wide. Caudal fin deeply forked; caudal lobes pointed, broad basally and slender distally, upper lobe longer and more slender in small- and medium-sized individuals, but lobes of more-or-less equal size and shape in very large individuals; caudal peduncle long, moderately broad and slightly laterally compressed. Free posterior rim of adipose fin equal to approximately half length of fin.

Lateral line curving over shoulder area, then straight, and briefly turned dorsad at caudal base; skin venulose over operculum, upper surface and sides of head and snout, and also near lateral line at its anterior-most section (i.e., opposite dorsal fin base); short oblique venules emanate downward along length of lateral line, and upward along entire length or (in smaller stadia) at least to vicinity opposite adipose fin.

Colour in life and alcohol varies from reddish-brown to dark golden-brown both dorsally and laterally, and yellowish to cream ventrally. Belly densely covered with fine brown speckles, unevenly with increasing body size; speckles absent from underside of head. All fins blackish, darker distally; paired fins darker dorsally. Lips yellowish. Barbels brown, darker dorsally. Peritoneum cream-coloured to transparent.

SALIENT OSTEOLOGY. Dorsal surface of skull with smooth striae and some rugose areas in otic region; anterior dorsomedian cranial fontanelle constricted midway, approximating elongate 'hourglass'-shape, and distinct, separated from relatively large remnant posterior fontanelle by a well-ossified epiphyseal bar; fontanelles extending from interorbital area nearly to base of supraoccipital. Müllerian ramus tapering and pointed, curving ventrad and posteriad slightly at tip; fourth neural spine with low to moderate forward ridge and thin, anterior-facing keel. Subvertebral cone moderately high and pointed, with aortic canal sealed (by lamellae) from immediately posterior to tip of cone to fifth vertebral
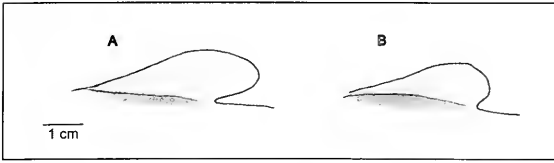
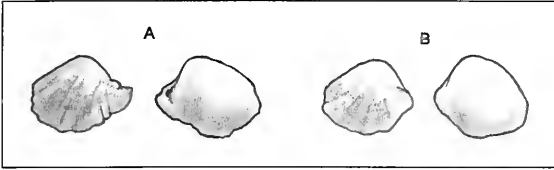**Fig. 4.** Relative shape of the adipose fin of A) *Galeichthys trowi* sp. nov., and B) *G. feliceps*.

Fig. 5. Left lapillus of A) *Galeichthys trowi* sp. nov., and B) *G. feliceps*, lateral and mesial surfaces.
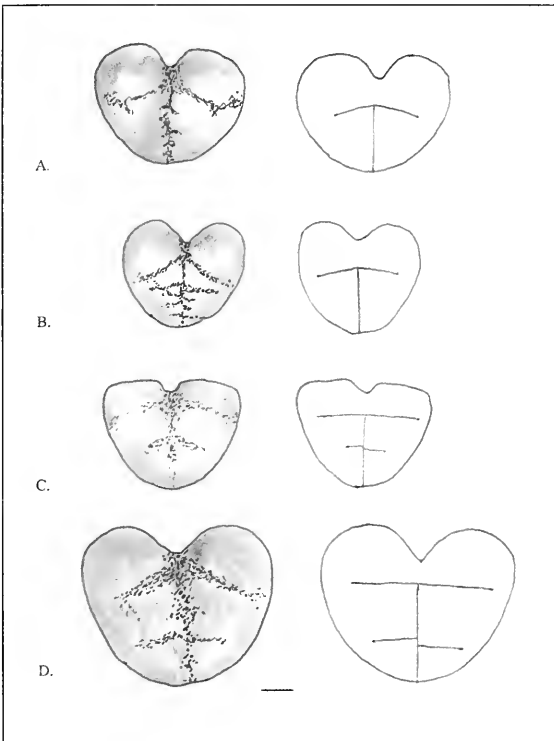

Fig. 6. Swimbladder of the four species of *Galeichthys* in dorsal view (left column) and schematic drawing showing internal septa and chambers in cross-section (right column): A) *G. ater* (from specimen 250 mm SL); B) *G. feliceps* (187 mm SL); C) *G. peruvianus* (285 mm SL); and D) *G. trowi* sp. nov. (370 mm SL); scale bar = 1 cm.

centrum medially (i.e., moderately extensive aortic tunnel). Posterior projection of tripus crescent-shaped, moderately wide and strong. Dorsal surface of supraoccipital process with longitudinal striae, flat or slightly convex in large individuals. Posterior border (or blade) of humeral process moderately ossified, smooth, fan-shaped and sexually dimorphic: broad (semi-circular) in mature females, and dorsoposterior shaft short; blade smaller and more angular than rounded in males, and shaft longer than posteroventral border.

Utricular otolith (lapillus) angular, thick and bulbous, with anteroventral projection and low posteroventral spur often evident. Mesial surface convex and smooth; lateral side convex, uneven and bumpy with some raised, radiating grooves. Short groove present near spur on flattened posteroventral margin. Margin smooth or slightly irregular.

SEXUAL DIMORPHISM. Most aspects of sexual dimorphism noted in other species of Galeichthys are present, in some form, as features of *G. trowi*. Posterior (humeral) process of the cleithrum is fan-shaped in both sexes, but broadly so (semi-circular) in mature females, with the posteroventral margin of this bone appearing stronger and better defined through the skin than appears in males. The ventral fins are equally long in males and females (cf. visibly or quantifiably longer in females of other species of *Galeichthys*: Lütken, 1875; Tilney, 1990; this study) and in both sexes extending to the first rays of the anal fin. The ventral fins are broad and spatulate in females, narrow with angular outer margins in males. The maxillary barbel and the pectoral fin spine are discernibly longer in females than in like-sized males; likewise, the adipose fin height is greater in females than in males.

ETYMOLOGY. From the Latinization of Trow, a tribute to the late Eugene Trow Jr., a student studying the biology and ecology of *Galeichthys* species in South Africa, who recognised the probable distinctiveness of this new species, and to his late father, Eugene Trow Sr., who collected many of the specimens upon which the description is based.

COMPARISONS. Taylor's (1986a) brief diagnosis for members of the genus *Galeichthys* is appropriate for *G. trowi* except for the total number of vertebrae, as more abdominal vertebrae and ribs are associated with a greater vertebral count in *G. trowi*.

G. trowi resembles *G. feliceps*, with which it is parapatric. Several superficial differences, such as adult body size, colour and some aspects of morphology, easily distinguish the two species. Either fresh or alcohol-preserved specimens of the new species and *G. feliceps* can be separated according to the following morphological and colour differences: viewed laterally, *G. trowi* is uniformly dark and the belly yellowish and pigmented by fine brown specks, whereas *G. feliceps* is obviously 'two-toned' (i.e., its dark dorsal colour grades to pale ventral colour along the length of the body), the

belly is stark white to cream and without pigment specks, and the anterior portion of the lateral line (below the dorsal fin base) is often lightened. The adipose fin colour of *G. trowi* is clearly demarcated (blackish) from its brown body colour, more so than normally appears in *G. feliceps*, while the adipose fin of the former is relatively large and the free posterior margin proportionately larger (Fig. 4). The angle of the posteroventral border of the opercle (easily seen through the thin skin) curves midway to near horizontal in *G. feliceps*, while the slope is gentle (diagonal), and the bone's concave dorsal margin is greater (visible in dissection) in the new species. The pectoral fin spine extends at vertical to slightly beyond the dorsal fin base in *G. trowi* but never beyond the dorsal fin base in *G. feliceps*. The dorsal fin spine is at most approximately two-thirds the height of the dorsal fin in *G. trowi*, but at least three-fourths the dorsal fin height in *G. feliceps*. *G. trowi* is also distinguished from *G. feliceps* by its dorsolaterally set eyes (entirely visible from above), laterally compressed caudal peduncle, premaxillary tooth patches pointed at their anterolateral corners, and a thinner band of palatal tooth patches that are slightly separated over the vomer. The utricular otolith of *G. feliceps*, as previously described by Frost (1925) and Hecht & Hecht (1978), is similar to that of G. trowi. However, Smale, Watson & Hecht (1995) refer to the lapillus of 'G. sp.' as typically more angular or boxish, with a posteroventral projection (spur), and a greater anteroventral protrusion on the anterior margin — observations that agree with mine (Fig. 5). Meristic differences are found in the number of pectoral fin rays (I, 12–13; cf. I, 9–12 in *G. feliceps*) and number of free vertebrae (50–52; cf. 45–48 in *G. feliceps*). *G. feliceps* is not recorded to attain more than approximately 40 cm FL.

G. *trowi* is dissimilar to the other African species in some features it shares with the South American species, *G. peruvianus*. These are a swimbladder with two bipartite posterior chambers (Fig. 6), palatal tooth patches slightly separated at the midline, ovate eyes, and a somewhat laterally compressed caudal peduncle.

BIOLOGY AND ECOLOGY. *G. trowi* inhabits the relatively warm, shallow coastal waters of the east coast of South Africa, and is not known to enter estuaries. Tilney (1990) proposed that its southern range may be limited by water temperature. *G. trowi* is likely to utilise both rocky reef and soft substratum environments (Tilney, 1990) and is probably inactive by day, remaining in caves and other forms of refuge offered by reefs (Van der Elst, 1981).

Aspects of this species' biology and ecology that might further distinguish it from *G. feliceps* — other than that it attains a larger size and does not enter estuaries — are not known. It feeds on small fish and crabs (King, 1997) and is preyed on by a large variety of sharks (J. Cliff, Natal Sharks Board, pers. comm. cited in Tilney, 1990). Gut contents in several specimens prepared for osteological study contained substantial amounts of crustaceans (prawn and

crab) as well as small fish. Two females, 435 and 450 mm SL, had more than 50 ripe eggs in each ovary, measuring up to approximately 1.7 cm in diameter.

SIZE. Recorded to 50 cm SL (Taylor, 1986b) [non *G. feliceps*], at least to 57 cm [TL?] (Smale, Watson & Hecht, 1995), and 58 cm FL, from a survey of shore anglers (A. MacDonald, Rhodes University, South Africa, pers. comm.).

DISTRIBUTION. East coast of South Africa (Indian Ocean), from northern KwaZulu-Natal Province to the Kei River, Eastern Cape Province. Observed as far north as Kosi Bay (B. Mann, Oceanographic Research Institute, pers. comm.), but frequently caught in the southern part of its range, from remote coastal areas between Port Edward and East London. *G. trowi* has never been taken from rivers or estuaries in this range, as recorded in checklists compiled by Whitfield (1980: Kosi, Sodwana, St Lucia estuaries), Harrison & Whitfield (1995: KwaZulu-Natal coastline) and Plumstead *et al.* (1989: Mbashe River, approaching the southern-most border of the former Transkei region).

Sympatric in at least the southern half of its range with the smaller, also marine species *G. ater* (the later infrequently recorded north of East London), and apparently parapatric with the morphologically similar, but smaller-sized, marine–estuarine species *G. feliceps*, at the southern end of its range.

FISHERIES. 'G. sp.' is recorded in the catches of the beach-seine fishery at Durban, 50–300 m offshore (Beckley & Fennessy, 1996). Large specimens (> 40 cm FL) are commonly caught from shore by hook-and-line anglers (mostly subsistence fishers), from Port Edward to Xora (unpublished surveys: S. Brouwer and A. MacDonald, Rhodes University, South Africa, pers. comm.).

BRIEF NOMENCLATURAL HISTORY OF THE SPECIES

The past nomenclature of the three valid, previously described species is relatively uninvolved, and, with the exception of Barnard's (1925) work (see below), no question of the specific distinctiveness of these fishes has arisen. Smith (1838–47) considered that the species he newly described as *Bagrus capensis* may have been one already described (= *Galeichthys feliceps*).

Gilchrist & Thompson (1916) based a description of *G. ocellatus* on a single specimen with a 'mottled colour' taken from the Swartkops River (Algoa Bay, Port Elizabeth, South Africa). Since the holotype had been lost, it was subsequently assumed that the authors had described a specimen of *G. feliceps* because of the locale and habitat from which it was taken. Later, Barnard (1925) attempted to give evidence in favour of uniting *G. feliceps*, *G. ater* and *G. ocellatus* under the name *G. feliceps* — contrary to differences he otherwise observed in colour, caudal

peduncle depth, and width of the premaxillary tooth patch. Barnard's (1925) decision to synonymise these had been misled by his re-examination only of specimens in the South African Museum, which he found to be inventoried as *G. feliceps* all males, and *G. ater* all females. My re-examination of the lost *G. ocellatus* holotype (in fair condition) reveals numerous characters that distinguish it as *G. feliceps* (e.g., shape of the head, caudal peduncle and opercle; adipose fin size; length of dorsal fin spine and maxillary barbel) and that the patterned skin of this individual may be an artefact of the mechanical means of its capture. Lütken (1875) stated in his original description of *G. peruvianus* that he could not assert the most characteristic differences between that species and *G. feliceps* (known to him only through the literature) yet he has successfully described the species' most salient features. Several later descriptions of *G. peruvianus* can be found in the works of Hildebrand (Hildebrand, 1925 and 1946; Meek & Hildebrand, 1923), wherein the species is correctly distinguished from many sympatric ariids (some having an uncertain specific status, even at present) and the unjustified generic designation, '*Tachisurus*,' briefly used by Eigenmann & Eigenmann (1888 and 1890), is disregarded. Some more recent descriptions of *G. feliceps* (e.g., Taylor, 1986a and 1986b) have included the newly described *G. trowi*. Although *G. ater* has been known from regions of South Africa along with *G. feliceps* since the 19th century, it has escaped the generic designations *Tachysurus* and *Arius*.

MATERIAL EXAMINED

Abbreviations for preparations are: A – alcohol preserved; C&S – cleared and stained for bone and cartilage; O – utricular otoliths removed; R – radiographed; DS – dry skeleton; SB – swimbladder removed.

Galeichthys ater
DIFS uncatalogued, (1, C&S) male, 205 mm SL, Indian Ocean, Plettenburg Bay, Eastern Cape Province.
DIFS uncatalogued, (1, C&S) 130 mm SL; Indian Ocean, Port Alfred, Eastern Cape Province.
DIFS uncatalogued, (1, partial DS) male, 235 mm SL, Port Alfred, Eastern Cape Province.
INVEMAR PEC 6799, (A with SB removed) female, 239 mm SL, same data as for SAIAB 63673.
MZUSP [gift to A. Marceniuk], (2, A) male 175 and female (with large eggs), 245 mm SL, same data as for SAIAB 63673.
SAIAB 11507, (1, A) female, 240 mm SL, Indian Ocean, Algoa Bay, Eastern Cape Province: Pollack Beach, 20m depth.
SAIAB 11999, (1, A) male, 220 mm SL, Tsitsikamma: Storms River mouth, Eastern Cape Province.
SAIAB 12770, (2, A) males, 205 and 245 mm SL, Indian Ocean, Plettenburg Bay, Eastern Cape Province.
SAIAB 17086, (1, A) male, 165 mm SL, Indian Ocean, Lubanzi, Eastern Cape Province.

SAIAB 34259, (2, A from which 1, SB removed) females, 245 and 320 mm SL, Atlantic Ocean, Olifantsbos, Western Cape Province.
SAIAB 56581, (2, A) male 200 mm SL and female 230 mm SL, Indian Ocean, Margate, KwaZulu-Natal Province, 36-39 m trawl.
SAIAB 63226, (1, DS) female, 222 mm SL, Indian Ocean, Port Alfred, Eastern Cape Province.
SAIAB 63672, (1, A) male, 232 mm SL, Indian Ocean, Hamburg: pool at Keiskamma River mouth, Eastern Cape Province.
SAIAB 63673, (4, A) from which 2, SB removed 170-255 mm SL, Indian Ocean, Tsitsikamma National Marine Reserve: Groot Bank, Station 93-6,9, Eastern Cape Province.
SAIAB 63674, (8, A) 210-262 mm SL, Indian Ocean, Port Alfred, Eastern Cape Province.
SAIAB 63675, (1, A) female (with gonads removed), 265 mm SL, Indian Ocean, Port Alfred, Eastern Cape Province.
SAIAB 63676, (1, A) female, 222 mm SL, Indian Ocean, Kenton-on-Sea, Eastern Cape Province.
SAIAB 63677, (2, A) male 170 mm SL, and female 220 mm SL (with SB removed), Indian Ocean, Tsitsikamma National Marine Reserve, Eastern Cape Province.
SAIAB 63803, NEOTYPE, (A/R) male, 190 mm SL, Indian Ocean, Tsitsikamma National Marine Reserve, Eastern Cape Province.
SAIAB uncatalogued, (3, A), Atlantic Ocean, Namibia, 1987, skiboat catch of R. Maadsen.

G. feliceps
DIFS uncatalogued, (1, C&S) 140 mm SL, Colchester: Sundays River, Eastern Cape Province.
DIFS uncatalogued, (1, C&S; SB removed) male, 220 mm SL, Swakopmund River, Namibia.
DIFS uncatalogued, (2, DS) male 290 mm SL and female 330 mm SL, Indian Ocean, Port Alfred, Eastern Cape Province.
MZUSP 87694, (2, A) female 180 mm SL and male 235 mm SL, same data as for SAIAB 63681.
SAIAB 41951, (3, A) 230-238 mm SL, Port Alfred, Eastern Cape Province.
SAIAB 60956, HOLOTYPE (A) of *G. ocellatus* Gilchrist & Thompson, 1916, 190 mm SL.
SAIAB 63225, (1, DS) male, 315 mm SL, Port Alfred: Kowie River, Eastern Cape Province.
SAIAB 63678, (1, A) male, 187 mm SL, Indian Ocean, Knysna, Eastern Cape Province.
SAIAB 63679, (1, A) female, 230 mm SL, Indian Ocean, Port Alfred, Eastern Cape Province.
SAIAB 63680, (2, A) females, 260 mm SL (w/ large eggs) and 295 mm SL, Swakopmund River, Namibia.
SAIAB 63681, (4, A) from which 2, SB removed 170-285 mm SL, Atlantic Ocean, Swakopmund, Namibia.
SAIAB 63682, (5, A) from which 1, SB removed females, 285-315 mm SL, Indian Ocean, Port Alfred, 40m depth, Eastern Cape Province.
SAIAB 63683, (3, A) females, 230-238 mm SL, Indian Ocean, Kenton-on-Sea, Eastern Cape Province.

G. peruvianus
AMNH 7939, (1, A/R) female, 222 mm SL, Pacific Peru, 1919, collected by R.C. Murphy.
AMNH 7963, (1, A) female (with ripe eggs), 345 mm SL, same data as AMNH 7939.
CAS 11942, (1, A/R) male, 250 mm SL, Bay of Callao (Lima), Peru, Dec. 1896-Jan. 1897, collected by L.A. Beardslee.
CAS 11962, (2, A/R) male 255 mm SL and female 285 mm SL, same data as for CAS 11942.
CAS 34326, (1, A) female, 310 mm SL, Bay of Callao (Lima), Peru, Nov. 1974, collected by F.B. Steiner.
CAS 47043, (1) male (DS only).
MCZ 7654, (1, A) female, 235 mm SL, Bay of Callao (Lima), Peru, May 1872, collected by Hassler expedition.
MCZ 7692, (1, A) 235 mm SL, same data as MCZ 7654.
SAIAB 60955, (5, A from which: 2, SB and O removed; 1, C&S and O removed) 86-230 mm SL, Bay of Callao (Lima), Peru, March 1995, collected by Walter Elliott.
USNM 077693, (1, A/R) male, 285 mm SL, Bay of Callao (Lima), Peru, July 1916, collected by R.E. Coker.
USNM 083138, (1, A/R) female, 220 mm SL, Pacific Peru, Feb. 1919, collected by Wilkes expedition.

ACKNOWLEDGMENTS

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Fish distribution and zonation along a tropical African river, the Rokel/ Seli River, Sierra Leone, West Africa

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Abstract. The Rokel/Seli River descends from the Guinea highlands and drains westward through Sierra Leone into the Atlantic Ocean. It lies within the Upper Guinean faunal region. The river has low mineralisation and buffering with conductivity varying from 14–55 µS and pH from 6.8–7.8 whilst temperature ranges from 21–32°C. Sampling along its length over a 12 month period showed that the number of species diminishes significantly upstream from 50 at the richest downstream point to 6 in the highest streams sampled. The major change occurs at the Bumbuna Falls which, at 136 m above mean sea level, also lies at the point of maximum change in gradient between the upland rhithron zone and the lowland potamon zone. The region above the Falls has 29 species, while 62 were recorded from the lowland reaches of the river. The Falls appear to be a barrier to fish movement as well as a barrier to the distribution of some species such as *Lates niloticus*. Yields from fishing also increase downstream from 0.87 t.km^{-1} in the upper area to 2.58 t.km^{-1} in the lowland reaches. Three fish freshwater zones were identified: an uppermost 'small cyprinid zone', typified here by *Barbus liberiensis*, starting around 290 m.amsl; a 'large cyprinid zone' characterised by *Barbus sacratus*, and *Labeo parvus* from above the Falls at 165–290 m.amsl, and a lowland zone, below 136 m.amsl, dominated by cichlids and catfishes. The large cyprinids move into the upper small cyprinid zone during the spawning migrations of the early rains. A total of 68 freshwater species was found throughout the system, rather higher than would be predicted from other African rivers. The fish assemblage is also very characteristic, having more than 35% of the species as regional endemics confined to they Upper Guinean region with the small cichlids and tilapias showing particularly high levels of endemism.

Résumé. Le fleuve Rokel / Seli descend des montagnes de Guinée et coule vers l'ouest, passe à travers Le Sierra Leone et se jette dans l'Océan Atlantique. Elle s'étend dans la région de la Haute Guinée. Le fleuve contient un faible degré de substances minérales avec une charge de conductivité électrique variant de 14 à 55 us et de 6.8 à 7.8 pendant que les écarts de température sont entre 21 à 32 degrés. La technique d'échantillonnage appliquée tout au long du fleuve pendant plus de 12 mois a démontré que le nombre d'espèces va diminuant sensiblement en amont du fleuve : de 50 en amont, cela atteint le point 6 en aval. Le grand changement se produit aux chutes Bumbuna, à 136 m au-dessus du niveau de la mer, dont le point culminant d'inclinaison est entre la haute-zone rhithron et la basse-zone potamon. La région au-delà des chutes contient 29 espèces pendant que 62 ont été enregistrées en amont du fleuve. Les chutes forment un obstacle tant au mouvement poissonnier qu'à la répartition de quelques espèces comme le *Lates niloticus*. Aussi le rendement de la pêche augmente-t-il de l'aval de 0.87 t.km en amont à 2.58 tkm dans les régions inférieures. Trois couches de poissons ont été identifiées : en grand nombre la zone de petit Cyprinidae classifié comme *Barbus liberiensis* variant autour de 290 metre au dessus du niveau de la mer ; une zone de grande Cyprinidae caractérisée par *Barbus sacratus* et *Labeo parvus* d'au-delà des chutes de 1665-290 metre au dessus du niveau de la mer et une zone inférieure, en dessous de 136 metre au dessus du niveau de la mer, est dominée par les Cichlidae et les poissons chats. Les plus grands Cypirinidae se déplacent dans la partie supérieure, en amont du fleuve, pendant la période de reproduction et pendant la période des pluies. Un total de 68 espèces d'eau douce étaient trouvées dans le « système » en nombre plus élevé que les prédictions faites au sujet d'autres fleuves africains. Le ban de poisson est aussi très caractéristique ayant plus de 35 % d'espèces comme la région endémique confinée dans la région de la Haute Guinée avec de petits Cichlidae et des espèces de *Tilapia*.
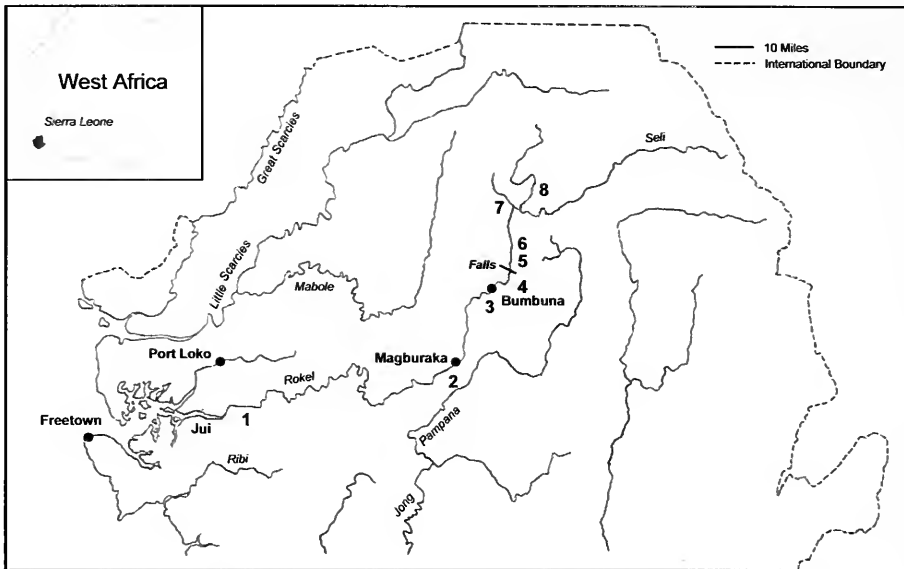
Fig. 1. The Rokel/Seli River in northern Sierra Leone showing sampling sites.

INTRODUCTION

The Rokel/Seli River, called the Rokel in its lower and the Seli in its upper reaches, is one of a series of narrow, more or less parallel river basins draining the Guinea highlands into the Atlantic, none of which are particularly long in African terms.

The region has been termed the Guinean (Lowe McConnell 1987), or the Upper Guinean (Leveque & Paugy 1999, Abell *et al.* 2008), while Daget (1962; Daget & Iltis 1965) termed it, perhaps climatically more correctly, the 'Atlantico-Guinean'. The region is more or less co-incident with the island of equatorial forest extending largely throughout South West Guinea, Sierra Leone, Liberia and southern Ivory Coast. It is surrounded by the savannah of upper Guinea and the 'Dahomey-gap'. This surrounding savannah region has been termed the Sudanien, based on the clear similarities of the fish assemblages occurring in river basins from the Niger to the Nile (Daget & Durant 1981; Lowe-McConnell 1987; Roberts 1975; Greenwood 1983).

Surveys of Sierra Leone rivers have been very patchy. Daget (1950) made a small collection, and sundry collections over the years, most notably Thys van den Audenaerde (1967). Essentially, most of the work up to this point has been taxonomic, the culmination of which is an overall guide to the taxonomy and identification of West Africa fresh water fishes (Leveque & Paugy 1984; Paugy *et al.* 2004), and a checklist for Sierra Leone (Paugy *et al.* 1990).

On the broader ecological front there has been one three-year study on the seasonal changes in the fish assemblage in the lower portion of another Sierra Leone river, the neighbouring River Taia (Payne *et al.* 1989). This not withstanding, there has

been no overall appraisal of the fish assemblages within Sierra Leone rivers and their distinctiveness as part of the Guinean region.

A pre-impoundment study of the Seli River for the Bumbuna Hydroelectric Project resulted in sampling the river from its upland headwater streams to the estuary (Fig. 1) thereby allowing both the river assemblage and changes in species composition down the length of the river to be categorised. Huet (1949) showed how fish species and communities change with altitude along temperate European rivers. Similar changes occur in tropical rivers including those of Africa (Payne 1986; Leveque & Paugy 1999) although they have not been systematically assessed, particularly within a single river basin. The relatively compact nature of the Rokel/Seli basin allowed this to be done over this year long survey.

METHODS AND SITE LOCATIONS

Site Locations

The Rokel/Seli River drains the uplands of northern Sierra Leone at altitudes of 300–400 m.amsl, where the coastal plain abuts the Guinea Plateau, and flows for some 300 km into the Atlantic through the estuarine Sierra Leone River. One particular feature of the river is the Bumbuna Falls, a cascade of around 30 m height, just above which is the site for the Bumbuna Hydroelectric Project. A significant question therefore was, to what extent do the falls influence the distribution of fishes?

Eight sites were selected in three regions, the upper, middle and lower reaches of the river, including above and below the falls (Table 1).

Table 1. Summary of study locations positioned on Rokel/Seli River (see Fig. 1 for locations).

Description	Region	Latitude	Longitude	Altitude (m)	No. sites
1. Rokel Bridge	Lower	8°35'05"N	12°43'16"W	11	1
2. Magburaka	Lower	8°44'12"N	11°56'21"W	86	2
3. Bumbuna Bridge	Middle	9°03'12"N	11°45'12"W	115	1
4. Below Bumbuna Falls	Middle	9°03'08"N	11°45'14"W	138	2
5. Below Bumbuna Dam	Middle	9°03'59"N	11°43'03"W	162	2
6. Above Bumbuna Dam	Middle	9°04'32"N	11°43'18"W	170	3
7. Kafogo	Upper	9°23'54"N	11°43'47"W	256	3
8. Fadugu - Bridge One	Upper	9°23'32"N	11°45'34"W	299	1

Sampling was also conducted above and below the Bumbuna Hydroelectric Dam which has been constructed above the falls, but has yet to be closed. A preliminary survey had been conducted at the site during an earlier phase (Payne & McCarton 1983). Further sites were sampled opportunistically on the estuary at Jui, and at two inflowing streams on the upper region at Kasasi and Kayakala. All sites were positioned with GPS and distances were calculated from the estuarine site at Jui.

Physico-Chemical Measurements
Water parameters measured at each site included pH, temperature (°C), conductivity (μS.K25) and dissolved oxygen (mg.ltr^{-1} and % saturation), with instruments being recalibrated between sampling sessions. These measurements accompanied each fish sampling occasion. The altitude of the sites was measured by GPS in meters above mean sea level (m.amsl).

Fish Sampling
Monofilament gill nets with mesh sizes of 10, 25 and 35 mm were usually set at two or three locations at each site and checked morning and evening over 14 days for each sampling period. Where possible the nets were also used as seine nets during the day.

Traps and dip nets were also used and, where fishing communities existed, particularly at Bumbuna Town, below the Falls, and at Magburaka and the Rokel Bridge, fishers were employed to collect fishes. The catches of men (main river) and women (small streams) were checked regularly and specimens purchased opportunistically.

Each of the eight locations was sampled in January, April, July and September 2006 to coincide with early and mid-dry season, and the beginning and end of the rains. The river shows considerable rise and fall with the rains and dry season but the flow is always significant. The Rokel/Seli has a limited floodplain.

Potential Yield
Semi-structured informal interviews were conducted with local fishers during the 2006 baseline fish survey in an attempt to estimate the potential annual yield available from the river. The interviews were held at Magburaka, Bumbuna and Kafogo. The potential yield was calculated for both the rainy season (May–October) and dry season (November–April) to account for seasonal variations in total catch.

Interviews were also used to calculate the average number of full-time equivalent fishers operating at the three locations each season. Total fishing effort (number of days fished per season) at each site was calculated from the average number of days per week and number of months fished by a typical fisher.

Total catch weight at each site and season was calculated for all species using their catch length (cm TL) converted into weight (g) using an appropriate length-weight relationship obtained from Fishbase (Froese & Pauly 2009). Finally, distance from the river source (km) was estimated for each location. This enabled a relationship between the potential annual yield and distance from the source of the river to be calculated for each season.

RESULTS AND OBSERVATIONS

PHYSICO-CHEMICAL ENVIRONMENT
Acidity
Water pH shows no clear trends with altitude, although it was notably higher during the lowest water levels in April. In January, pH values ranged between 6.8 at the Rokel Bridge and 7.4 at Bumbuna Bridge, whereas these increased in April to pH 7.5 and 7.8 respectively. In July, pH levels had started to fall at all sites from the high levels recorded in April, but remained above those recorded in January. In September, pH levels had returned to similar values reported during January.

The lower pH values in January, after the rains, were a result of low ionic concentrations and consequently poor buffering, together with humic compounds washed from the surrounding catchment area during the rains, which give the water a slightly acidic reaction and translucent brown colour.

Temperature
Declining water levels between January and April led to increasing water temperatures that are also related to altitude. For example, the water
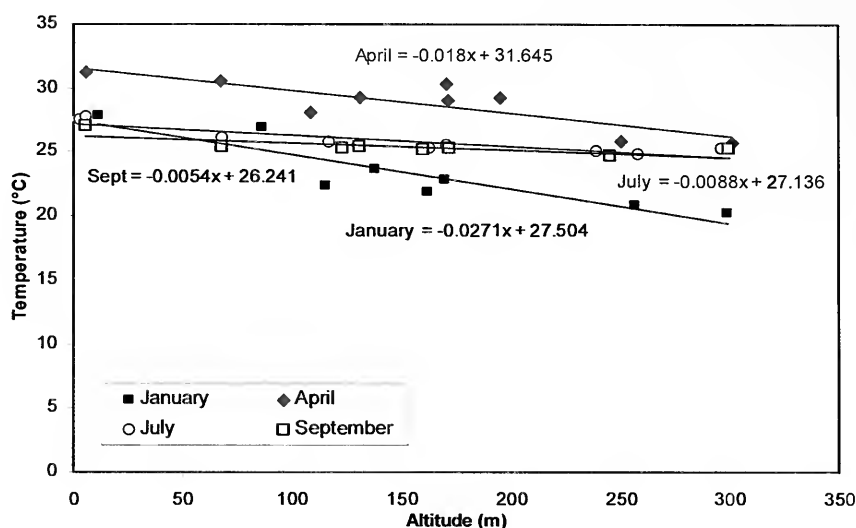
Fig. 2. Average water temperature measured at each sampling location during January, April, July and September 2006 with trend lines fitted.

temperature during January at Kafogo was 20.6°C, increasing downstream to 27.9°C at the Rokel Bridge. A line of best fit has been added to Fig. 2 to indicate the decrease with altitude, which was approximately 3°C/100m for January and 2°C/100m for April. Peak temperatures during the dry season in April ranged from 32°C near the estuary to 27°C at 300 m.amsl. During September, water temperatures had started to fall again, on average by 1°C to about 26°C, which was uniform across all sites. Most significantly, the temperature never dropped below 19°C.

Conductivity
Conductivity ranged between 14 and 55 μS.cm⁻¹ over the year. It tended to be higher in the dry season when lower water flows and evaporation can concentrate dissolved solids, and in April ranged from 35 to 55 μS.cm⁻¹. The high water levels and river flow rates observed during the July and September rains are associated with lower conductivity levels (14–29 μS.cm⁻¹).

Most African forest rivers have a conductivity of less than 100 μS.cm⁻¹ (Talling & Talling 1965; Welcomme 1985). They are waters of low mineralisation and generally very soft with extremely low calcium concentrations. The Seli, with other forest rivers in Sierra Leone (Payne 1975), clearly falls in this category. Although the water has a slight humic tint, its transparency, very low conductivity and pH varying around neutral suggests that this is a 'clear water' river, typical of tropical rivers whose water is derived through highly leached, old forest soils, according to the categorization of Sioli (1964).

Dissolved oxygen
The level of dissolved oxygen at each site showed little seasonal change in the upper reaches (7.5–9.5 mg.ltr⁻¹) but a wider range and generally lower

concentrations (5.0–7.2 mg.ltr⁻¹) in the lower regions. The highest degree of oxygenation (8.0–9.5 mg.ltr⁻¹) is consistently below the turbulent Bumbuna Falls. All sites were above 90% saturation levels over most of the year. The uppermost site registered the lowest value, with a low of 61% at the height of the dry season in April. The oxygen level varied between 5 and 10 mg.ltr⁻¹ at all times, well above any level that would cause distress to the fishes, particularly amongst groups such as catfishes which have evolved a range of ancillary respiratory organs which enable them to use oxygen from surface air when the water becomes deoxygenated, as it often does in swamps.

Fish Species Distribution
The results of the present survey, augmented by data from previous surveys, are shown in Table 2. The life colours of many of these species are poorly known or unknown and a photographic record is presented by Wakeford & Payne (2007). A series of photographs of species whose colours are not well known are included as Plate 1 and 2.

The most prominent species here was the golden-coloured barbel, *Barbus sacratus*, and the rock-haunting *Labeo parvus*. Both are typical of fast-flowing rocky rivers. *B. sacratus* is confined to the upper reaches above the falls, with only the very occasional small specimen being taken below the falls, probably having being washed down.

A further consistent feature of the assemblage above the dam was the presence of *Raiamas nigeriensis* and *R. steindachneri*. In July this site yielded a third species, *R. scarciensis*, which looks remarkably like a young tiger fish, *Hydrocynus forskalii*, with its slim silver body and the scarlet tail with a black edge (Plate 1). A second specimen was found below the Falls in October.

In the deeper pools with overhanging forest trees,

Table 2. List of species found at each site location during the 2006 baseline fish survey (●) and earlier collection of Payne (unpublished data) (○). Species status: ▲ regional endemic; C confined to some other small western coastal basins adjacent to region.

Family	Species	Jui - Estuary	Rokel Bridge	Magburaka	Below Falls	Below Dam	Above Dam	Kayakala	Kafogo	Fadugu	Total Length Max (cm)	Total Number	Status
Clupeidae	*Sierrathrissa leonensis*		○								6.7	1	C
Notopteridae	*Notopterus afer*		●	●	●						41.3	14	
Mormyridae	*Brienomyrus brachyistius*								●		9.9	1	C
	Hippopotamyrus paugyi			●	●	●	●				28.5	86	▲
	Marcusenius meronai			●			●	●			25.6	9	▲
	Marcusenius mento		○								18.2		
	Marcusenius thomasi		●	●	●		●				23.4	63	▲
	Mormyrops breviceps			●	●						47.1	4	C
	Mormyrops anguilloides			●	●						28.8	3	
	Mormyrus tapirus		●	●	●						50.0	20	▲
	Mormyrus cf *rume*		●								30.0	1	?
	Petrocephalus pelligrini			●	●	●	●	●	●		15.0	49	▲
	Petrocephalus levequi			●	●						13.8	2	▲
Characidae	*Brycinus longipinnis*			●	●	●	●		●		13.5	89	C
	Brycinus macrolepidotus		●	●	●						50.0	20	
	Hydrocynus forskalii		●	●	●						36.0	12	
Distichodontidae	*Ichthyborus quadrilineatus*			●							15.5	5	▲
	Neolebias unifasciatus				●	●					2.3	2	
Cyprinidae	*Barbus ablabes*					●	●		●	●	12.0	125	
	Barbus sp.					●	●	●			19.4	44	?
	Barbus sacratus				●	●	●	●	●	●	37.4	104	▲
	Barbus leonensis						●		●		-	2	
	Barbus liberiensis								●	●	11.0	12	▲
	Labeo coubei			●	●						50.5	2	
	Labeo parvus		○	●	●	●	●	●	●		41.7	203	
	Leptocypris guineensis				●						13.5	1	▲
	Raiamas nigeriensis			●	●	●	●		●	●	18.4	71	▲
	Raiamas scarciensis				●						23.1	1	
	Raiamas steindachneri				●	●	●	●			18.8	34	▲
	Varicorhinus wurtzi		●	●	●						45.3	29	C
Bagridae	*Auchenoglanis occidentalis*		●	●	●						46.4	5	
	Chrysichthys johnelsi			●	●						25.6	6	C
	Chrysichthys nigrodigitatus		●	●	●						34.6	43	
	Chrysichthys maurus		●								-	2	C
Schilbeidae	*Schilbe mandibularis*				●						20.2	10	▲
	Schilbe micropogon			●	●						24.2	17	C
Amphiliidae	*Amphilius rheophilus*					●					5.2	3	
Claridae	*Clarias anguillaris*				●			●			31.0	53	
	Clarias buttikoferi									●	42.4	1	C
	Clarias laeviceps djalonensis		●		●						49.2	4	▲
	Heterobranchus isopterus			○			●	●			43.3	8	C
Malapteruridae	*Malapterurus electricus*		●	●	●						26.6	8	

Table 2 cont...

Family	Species										Length	N	
Mochokidae	Synodontis annectens	●	●								-	1	C
	Synodontis cf filamentosus		●								17.5	3	
	Synodontis ansorgii		o								17.2	5	▲
	Synodontis thysi		●								18.8	2	▲
	Synodontis tourei	●	●	●							24.5	24	
	Synodontis waterloti		●	●							13.1	4	C
Centropomidae	Lates niloticus	●	●	●							37.0	17	
Cichlidae	Hemichromis bimaculatus					●					6.5	1	
	Hemichromis fasciatus	o	●	●		●	●		●		25.0	115	
	Anomalochromis thomasi		●								5.2	1	▲
	Pelvicachromis humilis			●							6.0	1	▲
	Sarotherodon caudomarginatus	●	●	●							16.3	4	▲
	Sarotherodon occidentalis	●	o						●		25.0	3	C
	Sarotherodon melanotheron	o									25.9	-	C
	Tilapia brevimanus	●	●	●							26.8	75	▲
	Tilapia buttikoferi		o								26.5		
	Tilapia louka	o	●	●		●	●		●		30.0	178	▲
	Tilapia joka	o					●				12.6	1	▲
	Tliapia guineensis	o									30.1	-	C
	Tylochromis leonensis	●	●	●							21.9	36	▲
	Tylochromis jentinki		o										
Eleotridae	Kribia kribensis		o										▲
Gobidae	Awaous lateristriga		●	●		●	●				15.3	7	C
Anabantidae	Ctenopoma kingsleyae		●	●		●	●	●	●	●	19.7	49	
Mastacembelidae	Mastecembelus liberiensis			●					●		28.5	5	C
Aplocheilidae	Epiplatys fasciolatus.		●						●		-	7	
Mugilidae	Liza grandisquamis	●		●							48.4	2	
	Other estuarine species	●									-	-	
TOTAL (ALL SPP)		20	25	50	38	16	19	6	17	8	-	1,734	
TOTAL ABOVE/Below FALLS (FW only)			62				29						
TOTAL FW SPECIES				68									

typical calmer water species such as the anabantid *Ctenopoma kingsleyae*, the mormyrid, *Marcusenius thomasi* and the predatory cichlid *Hemichromis fasciatus* were commonly found. However, this last species occurs almost ubiquitously along the river (Table 2).

The rivers of Sierra Leone are characterised by their cichlids, particularly their distinctive *Tilapia* species. However, immediately above the dam, as above the falls, only *Tilapia louka* was common. Some of the larger individuals, even in January, were developing their breeding colouration of bright red on the edge of the dorsal fin and the corners of the caudal fin together with a bright gold body colour with red in the pectoral region. This was noted through to July.

The number of catfish species in the samples increased towards the rains as more moved upstream to spawn. The most distinctive catfish groups below the falls were the schilbeids and of the genus *Synodontis*. These were entirely absent above the falls. The *Synodontis* species were particularly diverse, and seven species were found in the river as far as Magburaka. By Bumbuna (138 m.amsl) below the falls, however, there were only two species,

S. tourei and *S. waterloti*, presumably as the river course becomes steeper and habitats become less favourable to *Synodontis* spp. generally. Upstream of the falls they disappear completely (Table 2). These last named species we examined for taxonomic distinctness since *S. tourei* had previously only been found in the upland streams of the Fouta Djallon of the Guinea Highlands, within the catchment area of the Upper Bafing basin which flows into Senegal. Similarly, *S. filamentosus* had also not previously been found in Sierra Leone but has been found in the Upper Niger. The Rokel population has the very characteristic filamentous extension to the dorsal fin which almost reaches the base of the caudal fin (Paugy *et al*. 2004). It may, therefore, be a variant of *S. filamentosus* or a closely related but previously unrecognised species. Bearing in mind the proximity of the Upper Niger basin to that of the Seli, the headwater streams maybe with 20–30 km from each other, it would not be surprising if species from the Upper Niger had reached the Seli during their evolutionary history.

Schilbeids are fast-swimming, silvery open water species. Two species were recorded in the survey. Previously these were ascribed to the genus

Eutropius, but a recent revision has subsumed them into the widely distributed genus *Schilbe* (De Voss 1995). Thus they are now referred to as *Schilbe micropogon* and *S. mandibularis.* Neither were found above the falls and both are characteristic Upper Guinean species.

Another group which proved to be diverse within the fish assemblage of the Seli River were the Mormyridae. Of the 11 species taken, most occurred as far as the falls and five were also found above the falls. One species, *Brienomyrus brachyistius,* was only taken in the streams of the upper reaches.

Extended fixed gill nets, some over 100 m long, were set by fishermen across the large, deep pool immediately below the falls. The species caught had already been recorded but they did produce very large specimens of *Brycinus macrolepidotus* of up to 50 cm long (Table 2). These specimens had bright red fins and areas on the flanks of adults more than 35 cm. In the Chad basin this species is known to grow to 53 cm and 2.9 kg. The Guinean and Sudanian forms vary in that the fins are generally orange, but only in the River Cavally is the colour red/vermillion, as for the Rokel/Seli specimens (Leveque & Paugy 1984). There is no mention of the four black longitudinal lines that also appear in the adults from the Seli population, which may be a characteristic of the Guinean form. Similarly, large specimens of the cyprinids *Labeo parvus* and *Varicorhinus wurtzi* were also caught (Table 2).

Fishermen below the falls stated that in January the water is still quite cold (see Fig. 2) and that better catches were taken in the warmer months of February and March, i.e. during the dry season. Peak catches, however, were taken during the beginning of the rains when the fish were moving. Asked if fish could move up the falls, they were unanimous in asserting that they could not, but that fish were washed down. This is probably the case for *B. sacratus* since a few smaller individuals were found below the falls, but the fishermen also stated that this species is found all the way up to Kafogo, which proved to be correct (Table 2). It is worth noting that *V. wurtzi* was found at a number of points downstream and may well be an ecological replacement species for *B. sacratus,* i.e. occupying a similar niche downstream. Quite large specimens of both were taken in the present survey. Fishermen at Kafogo stated that 10 years ago the golden fish (*B. sacratus*) were "bigger than a sugar bag" (75 cm) although the use of dynamite in the 1990s destroyed the population and such big individuals had not been seen recently. The maximum recorded size in the survey was 37.4 cm (Table 2); such large fish do still exist but presumably much less frequently in the opinion of the fishermen. Dynamite fishing has been a problem in Sierra Leone. It is illegal under Sierra Leone law but still occurs. The damage referred to above by the fishers was related to a period of mineral exploration by expatriate companies.

The fishermen said that species, such as the Nile perch, *Lates niloticus,* the tiger fish, *Hydrocynus forskalii,* and the large characin, *Brycinus macrolepidotus,* do not occur above the falls. This ultimately proved to be correct (Table 2). The largest Nile perch was taken near Bumbuna Bridge measuring around 90 cm (Table 2), but none were ever seen above the falls.

Sampling in the upper reaches of the river included samples at sites at a headwater stream near Fadugu, the highest point sampled (299 m.amsl), and a little beyond at Kafogo which is on the banks of a larger tributary (Table 2). The branch at Kafogo (Table 2) showed an assemblage similar to that in the vicinity of the dam with *B. sacratus, L. parvus, H. fasciatus* and *Ctenopoma kingsleyae.* Other species included the large tilapia, *Sarotherodon occidentalis,* from one of the larger pools, and the catfish *Heterobranchus isopterus. Sarotherodon occidentalis,* as a microphageous detritus/algal feeder (Payne & McCarton 1983) should also be more typical of lower reaches of the river. However, this may be of feature of the low gradient of the river at this point, with a series of riffles and quite calm pools (Table 2).

The second much smaller stream near Fadugu, contained mainly small *Barbus* species including *B. liberiensis* along with the characin *Brycinus longipinnus,* both of which are typical of small, cooler headwater streams in the region. Unusually, the water in both branches was quite turbid rather than clear. Again, this could be due to the low gradient here although deforestation of the surrounding hills of the catchment area may also be significant.

Catfishes became much more common downstream, particularly at the Rokel Bridge where the two species of *Chrysichthys* seem to predominate, along with an *Auchenoglanis* species and a number of *Synodontis* species (Table 2).

At Magburaka a fisher's catch from a swamp during January included a large number of young-of-the-year of the catfish, *Clarias,* demonstrating the lateral migration of such species up small streams and marginal swamps to breed. The catch also contained the colourful small cichlid *Anomalochromis thomasi,* which is to be found in smaller streams. A small clear water, inflowing stream also yielded *Brycinus longipinnis,* typical of such habitats, as described for the inflowing stream at Bumbuna.

A final component of the species assemblage in the Rokel/Seli is the estuarine element. The conditions at the Rokel Bridge are under tidal influence but were freshwater when sampled although a number of estuarine species are found here. These include a sole, *Cynoglossus* sp., a pompano, *Caranx* sp., and a common croaker *Pomadasys jubilini.* Not found in the present survey but recorded earlier have been the two tilapias, *Tilapia guineensis* and *Sarotherodon melanotheron* (Payne unpublished data). These are exclusively confined to estuaries and are widely distributed in those of Sierra Leone (Payne 1983). They add another element to the remarkable diversity of tilapia-like cichlids in the rivers system.

One estuarine species, the grey mullet, *Liza grandisquamis,* was recorded as far up as Magburaka, some 140 km from the estuary, and this during the height of the rains when the influence of freshwater was at a maximum. A species of goby, *Awaous*

lateristriga, was found above the falls at Bumbuna, at least 190 km upstream from the estuary. However, gobies of the genus *Awaous* are diadromous and live their entire adult lives in fresh water. The Malagasy, Caribbean and Central American congeners of *Awaous lateristriga* are routinely found above major waterfalls at altitudes in excess of 500 m.amsl.

Changes in Abundance

The variety of methods used suggests that total numbers caught by species only give an approximate indication of abundance (Table 2). Species such as *Labeo parvus*, *Hippopotamyrus paugyi* and *Tilapia louka*, however, emerge as generally quite common whilst some, such as *Raiamas scarciensis* and *Clarias beutikoferi*, are only known from one or two specimens.

The major seasonal shift show by large numbers of *Barbus* species, particularly *B. sacratus*, along with *L. parvus* and the small *Brycinus longipinnis* appearing in the upper reaches during April and July. This is consistent with the upstream spawning migrations known for these types of fishes with the advent of the rains (Welcomme 1985; Payne & McCarton 1983). In April also, large numbers of *Synodontis* spp. appear at Magburaka as if moving upstream in a spawning migration. They do not, however, move above the falls which appears to be a barrier to fish movement.

Yield Estimate from the Rokel/Seli River

Higher potential yields are taken by the fishers during the dry season than in the rainy season. This may increase by a factor of 20. Thus at Bumbuna, for example, total estimated catches increased from 144 kg.km^{-1} during the rainy season to 2.7 t.km^{-1} during the dry season.

An average of both seasonal results was used to illustrate the expected annual yield available from the Rokel/Seli River. Average estimated yields increase downstream. The relationship between the distances from the source of the river and yield is not linear, but is described as a power function similar to Welcomme (1976) where yield = 0.053 * d 0.8082, where d is the distance (km) from the source of the river. The average annual potential yield increases from 0.87 t.km^{-1} in Kafogo, to 1.42 t.km^{-1} in Bumbuna, and 2.58 t.km^{-1} in Magburaka. The surveyed yields here are rather lower than those predicted by the relationship of Welcomme (1976) but they are most likely minimum values, since catches from a number of other part-time and subsistence fishers are unlikely to have been accounted for, including women and children using hand nets, hook and cast nets. The arrival of seasonal fishers with powerful gear has been noted for the River Taia (Payne *et al.* 1989) and was reported in the Rokel and seems to be a feature of Sierra Leone river fisheries which has been similarly unaccounted for in this study.

DISCUSSION

Species assemblages and zonation

There clearly is a progressive reduction in the number of species upstream (Table 2). Exceptions to the trend are the lowest altitude sites at the Rokel Bridge and the estuary at Jui, but these were only sampled on one occasion each as opposed to four (January, April, July and September) at the other sites. The relationship between species number and elevation is shown in the river profile (Fig. 3). A regression of species number on altitude, excluding the under-represented site at the Rokel Bridge, showed a highly significant inverse relationship (r = 0.86, p = 0.01)

The species number falls from 41 at Magburaka, where the river is wide with the deep-flowing, depositional nature of the lowland portion of the river, to eight at Fadugu, at which point the river is little more than a turbulent stream. The river from Fadugu to the falls follows a very steep course (Fig. 3) typical of the erosional, fast-flowing rhithron zone typified by more species (16–19) than at the upper stream at Fadugu, but far fewer than the downstream lowland portion. The rocks of this region are also typically covered at the waterline by encrusting plants of the Podostemaceae (Payne 1986). The construction of the dam has had little effect on diversity at this point judging from species numbers above and below, probably because it is not yet functional (Fig. 3; Table 2).

Species number differs little between Magburaka to the point below the falls, while the Falls represent the greatest species discontinuity along the river system, as well as the point of maximum change in slope, marking the transition from lowland (potamon) to upland zones (rhithron) of the river. Thus, compiling the total numbers of freshwater species gives 55 for below the falls and 29 for above. In a comparable review of the Ganges basin where the change from upland to lowland sectors is almost as distinctively marked in its descent from the Himalayas, some 54 species were found in the upland sector and 107 from the lowland (Payne et al. 2004), a very similar ratio to that for the Rokel/Seli.

In comparable fashion, a number of species which occur in the Benue River have been unable to colonise the Chad basin because of the Gauthiot Falls (Leveque & Paugy 1999). There are similar cases in rivers descending the Upper Niger basin from the Fouta Djallon where, for example, the number of species found below the falls at Tinkisso was 19 compared to eight above (Daget 1962). The relative reduction is also similar, although it is not clear whether this is due to progressive increase in slope or altitude or whether it is due to solely to the falls. On the River Mono, Paugy & Benech (1989) noted that species tended to increase downstream towards an asymptote, which seems to be to case here. The same pattern is seen on a small montane river on the Freetown Peninsula, Sierra Leone where the number of species on the coastal strip at 25 m.amsl was 16,
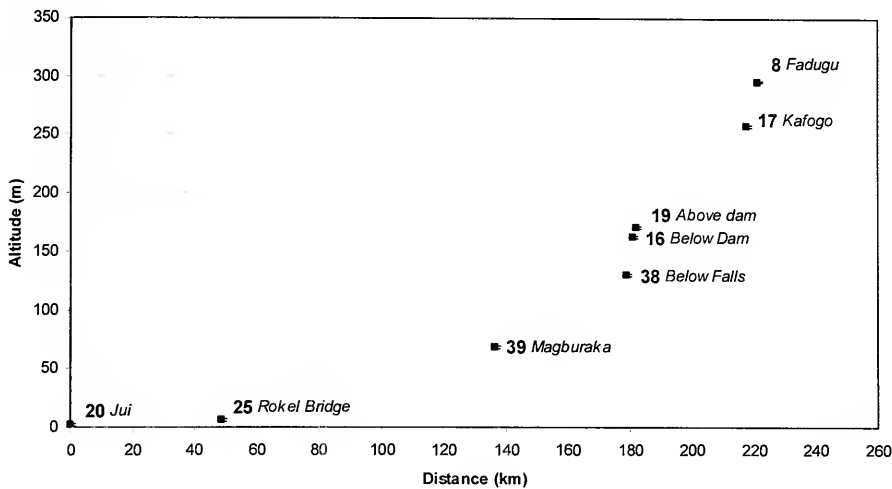
Fig. 3. The number of species taken at each location in relation to altitude (meters above mean sea level) and distance from estuary (km).

declining to four at 100 m.amsl and further to two species at 400 m.amsl (Payne 1986).

Of the species above the falls, nine are not found lower down. Of these, four are small *Barbus* species. Of the small barbs, *B. liberiensis* is only found at the two highest sites (260 m.amsl and 295 m.amsl) where the streams are fast flowing. In the mountainous terrain of the Freetown Peninsula *B. liberiensis* was frequently found to occur alone at the highest points of streams at altitudes of 250–400 m.amsl in a similar fashion to the higher sites on the Seli (Payne 1975, 1986). On the Peninsula in the high streams where *B. liberiensis* is not found, the last species remaining is the small cichlid *Hemichromis bimaculatus* (Payne 1986). This species has been found in one location above the dam on the Seli but is uncommon (Table 2). Daget (1962) commented that above waterfalls the high streams of the Fouta Djalon massif in the Guinea highlands were dominated either by small barbs or by *Hemichromis*, but never by both, a feature he ascribed to the predator pressure on the barbs by *Hemichromis* when they are prevalent. The same feature is demonstrated in the upper regions of both the Seli River and the Peninsula streams.

Another characterisitic species of small fast-flowing streams in the region is the small catfish, *Amphilius rheophilus*, with suctorial mouthparts which enable it to cling onto the underside of rock surfaces when steams are in spate. It was only found in a small inflowing stream in the upper reaches in the aftermath of the rains.

The fish assemblage above the falls is characterised by cyprinids generally such as *Barbus* species including *B. sacratus* and also *Labeo parvus* among the larger species — although the latter is widely distributed throughout the whole system wherever there are rocks — and two of the micropredator *Raiamas* species. In Europe, the turbulent, well-oxygenated upper reaches of rivers are characterised by strong swimming, often migratory, salmonids, and the lower reaches are characterised by deep bodied cyprinids (Huet 1949). The salmonid role appears to have been taken over by the cyprinids in west African rivers, particularly the larger species, which are also usually migratory. So *Barbus sacratus* could be regarded as the trout of the Seli which, given the significance of trout in European water management, could make it a key indicator species of anthropogenic impacts.

Below the falls a high proportion of species are not found above. A large number of these are catfishes, particularly *Synodontis* spp. Of the 15 catfish species only found in the lowland reaches, eight are *Synodontis* spp. Catfishes are well adapted to the often turbid, slower-flowing waters in this region, with highly tactile barbels which facilitate the use of touch and chemical stimuli when light is low (Lowe-McConnell 1975). Most catfish species are bottom dwellers, but the two *Schilbe* species are midwater predators and very mobile. The falls may present a physical barrier to such mobile species or to any migratory type, which includes most cyprinids and catfishes.

There are also cyprinids below the falls including the ubiquitous *Labeo parvus* and another *Labeo, L. coubie*. Another larger cyprinid *Varicorhinus wurtzi* which does not appear in the upper reaches, seems to replace *B. sacratus* as the large upstream species. *V. wurtzi* is rather darker and deeper bodied than the more fusiform *B. sacratus*; *L. coubie* is also a deeper bodied species which often typifies fish of the slower moving, turbid lower reaches. Proportionally, however, the cyprinids are much less significant in the lower reaches compared to the upper, with nine species appearing in the upper river above the falls and four in the lower reaches (Table 2).

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Most larger cyprinid and catfish species migrate upstream during the early rains. Consequently such species tend often to decline when dams are closed and lacustrine conditions replace riverine (eg. Lowe-McConnell 1987). This could be expected when the Bumbuna Dam is finally closed and a reservoir forms.

Neither of the two specialist top predators, *Lates niloticus* and *Hydrocynus forskalii*, is to be found above the falls. In this respect, it is notable that *L. niloticus* is thought never to have naturally colonised Lake Victoria or Lake Edward from the rest of the Nile system due to the intervening presence of falls or rapids below the lake outflows. It has, however, been suggested that strict top predators are often large in size and are consequently generally restricted to lower basin zones (Welcomme et al. 2006). Another species that has not made the transition is the characin, *Brycinus macrolepidotus*, which can also grow to a large size (Table 2).

A group particularly characteristic of the lower river below the falls are the cichlids, especially the tilapiine cichlids, the nest-guarding leaf chewers, *Tilapia*, and the paternal/biparental, mouth-brooding, microphageous *Sarotherodon* species (Trewavas 1983). In addition, there are two *Tylochromis* species (Table 2) which are of similar size and shape, and which are also mouth-brooders. Stiassny (1989) identified three species in the region of which *T. leonensis* and *T. jentinki* have been found in the Rokel/Seli River. More specific information on their feeding and reproductive ecology will be the subject of a separate paper.

In this relatively small river basin eight species of true tilapia have been found plus the *Tylochromis* species (Table 2). In the entire Nile basin there are only four *Tilapia* species (Payne & Collinson 1983), whilst the neighbouring Niger basin has just six. Even in Lake Malawi, renowned for its cichlid diversity, there are but six *Tilapia* species (Philippart & Ruwet 1982). The third tilapine genus, *Oreochromis*, is completely absent from the Rokel/Seli system, even though it is common in many African lakes and rivers further east, including the Niger. The diversity of the tilapia-like cichlids is greatest in the lowland potamon zone where all species are found. Two species, *T. guineensis* and *S. melanotheron* are confined to the estuary where they live and spawn in waters of up to 36 ppt salinity (Payne 1983). Of the others, *T. louka* has spread throughout the whole system and *T. joka*, a small, rock-dwelling species occurs wherever there are rocky areas in quieter waters either above or below the falls. *Tilapia joka* is unusual for a tilapia, in that field observations show it feeds and breeds around holes and crevices in rocky areas.

Sarotherodon and *Tylochromis* species tend to be confined to the lowland sector below the Falls. One exceptional specimen of *S. occidentalis* was taken well upstream at Kafogo (Table 2) although this was in a relatively calm, deep pool, untypical of the sector. What this does show, however, is that when the habitat is suitable, a species can colonise it. These tilapia-like species are relatively sedentary and their parental behaviour seems to be better adapted to calmer waters since all species need to make nests which requires an abundance of sedimentary areas, a characteristic of the depositional lowland sectors. These features, together with the microphageous feeding habit of *Sarotherodon*, which feed on plankton and detritus (Trewavas 1983), tend to favour tilapias when dams create lacustrine conditions. After the Akosombo Dam created the Volta Lake on the River Volta in Ghana, *S. gallileus* became a major species in the commercial fishery (Lowe-McConnell 1987), while noting that *O. niloticus* was the most commercially important species in Volta Lake. Significantly, in a small lake formed from a flooded quarry within the catchment area of the lower Rokel, *S. occidentalis* was found to be very abundant. It is probable, therefore, that *S. occidentalis* will become a feature of any fishery that develops behind the Bumbuna Dam when it is finally closed.

The high diversity of the tilapia-like cichlids has two further applied consequences. First, all but the two estuarine species were found to be confined to the Guinean region and the majority are regional endemics, which, given the significance of tilapias in aquaculture, should be conserved as a great pool of genetic diversity for aquaculture in the future. Second, given the need for this conservation and noting that there are no endemic *Oreochromis* species, the introduction of exotic species such as *O. niloticus*, which has already happened on a limited scale for aquaculture in Sierra Leone, should be discouraged, given the great damage already done to tilapia genetic diversity by escapees elsewhere in Africa. Faced with this same problem, the Government of Malawi for example, has decreed that only their endemic tilapia species should be used for aquaculture. Given their very different reproductive systems, the likelihood of introgressive hybridization between *Oreochromis* and *Sarotherodon* is slight. However, *Oreochromis* is characterized by both greater fecundity and extreme sexual precocity, characteristics which would allow them to out-compete and ultimately displace *Sarotherodon* species if they escape, which they inevitably will.

It is possible to identify zones, after the manner of Huet (1949), for African rivers (Illies & Botosaneanu 1963). Four zones, including the estuary, have been characterized in the rivers of the Atlantic Forest region of Brazil (Ferreira & Petrere 2009). The uppermost, from low order streams, for the Rokel/Seli at about 260 m.amsl to 300 m.amsl, is characterised by small *Barbus* species, specifically *B. liberiensis*. On the Peninsula and in the Fouta Djallon some of the streams in the upper zone instead have only *Hemichromis bimaculatus*. Below this small *Barbus* zone, down to the junction with the potamon boundary, is a zone characterised by large cyprinid species, in this case *Barbus sacratus* and *Labeo parvus*, with the former being the most characteristic. During the upstream spawning migrations in the early rains, these species may move up into the headwater, 'small *Barbus* zone' to spawn. In the Ganges river there is a distinct parallel, with a large cyprinid zone

starting at the rhithron/potamon boundary but in this case characterised by the cyprinids *Schizothorax*, the snow 'trout', and *Tor*, the mahseers (Payne et al. 2004).

Below the large cyprinid zone, throughout the lowland rhithron sector is a zone characterised by cichlids and catfishes. In the Rokel/Seli they account for 13 and 16 species respectively. In other African river systems, the larger cichlids may be less diverse and better represented by their relative abundance. Below this lower rhithron catfish/cichlid zone lies the fourth zone, the estuary.

There is one further zone or distinctive habitat. This is lower order inflowing lowland streams. These characteristically hold the young of the year of main channel species, such as *Clarias*, *Mastacembelus* and mormyrids together with some distinctive smaller species, especially cichlids such as *Pelvicachromis humilis* and *Anomalochromis thomasi* together with cyprinodonts such as *Epiplatys* spp., and some more widely distributed small stream species like *Brycinus longipinnis*. These small species essentially on the more isolated margins of the river network often have a high degree of endemicity. These are also the populations which were seen to be most exploited by the women and children with hand nets. It could be that this relatively low technology fishing could actually be having a disproportionate impact on biodiversity.

Relative Diversity
The total number of freshwater species found during this survey on the Rokel/Seli Basin was 68 (Table 2). A general relationship between the total number of species occurring in a basin and its area has been described for Africa by Welcomme (1985) as: N = 0.449 A 0.434, where N is species number and A is basin area (km^2). Since the basin area of the Rokel/Seli is 10,620 km^2 this means that the most probable expected number would be 39. The Rokel/ Seli has rather more than this and perhaps could be a biodiversity hotspot for fish. The appraisal of Abell *et al.* (2008) suggests a high number of species in the region compared to other areas further indicates a hotspot.

A checklist of fish species in Sierra Leone from all sources, including specimens in major museums, suggests a number of 95 species (Paugy *et al.* 1989). One of the contributing factors to the Rokel/Seli not attaining this is the lack of lowland freshwater swamps in the coastal region, which often contributes significantly to fish diversity (Abell *et al.* 2008). There were also some species missing which are common elsewhere, such as *Hepsetus odoe*, although this is regarded as a predator of smaller tributaries.

Of the species recorded (Table 2) 35% (24) of those identifiable are found only in the Guinean region of which six, *Marcusenius meronai*, *Petrocephalus levequi*, *Leptocypris guineensis*, *Raiamas scarciensis*, *Clarias laeviceps* (as its subspecies, *dialonensis*) and *Synodontis thysi*, are endemic to Sierra Leone and south west Guinea (derived from Trewavas 1983, and Paugy et al. 2004). A further 24% are also only to be found

in some of the other small coastal basins outside the region leaving fewer than 40% in common with other basins across wider Africa, including the neighbouring Niger. A comparative assessment of species assemblages between regional rivers will be the subject of a separate publication, but suffice to draw attention to the distinctiveness of the fish assemblage of the Seli/Rokel. This distinctiveness may have come about by the periodic interpluvial spread of the surrounding Sahara, in step with the interglacials, over geological time thereby further isolating the region and producing an 'island effect' which promoted differentiation.

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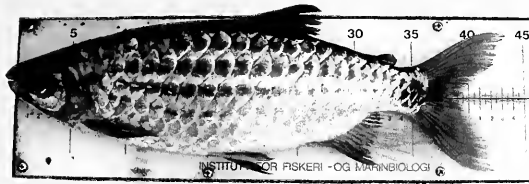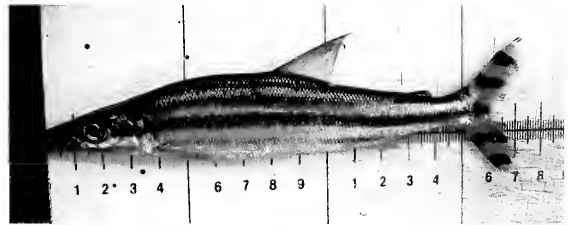
PLATE 1

Mormyrus tapirus, 509 mm SL, Mgaburaka, Rokel/
Seli River (Robert Wakeford)

Mormyrops breviceps, 473 mm SL, Mgaburaka,
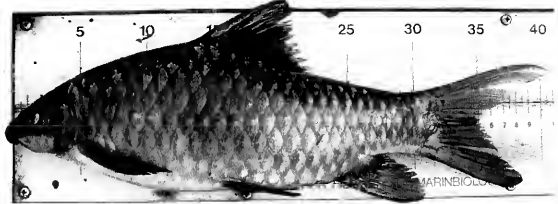Rokel/Seli River (Robert Wakeford)

Brycinus macrolepidotus, 448 mm SL, below
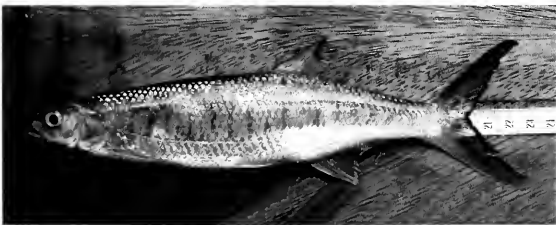Bumbuna Falls, Rokel/Seli River (Robert Wakeford)

Ichthyborus quadrilineatus, 191 mm SL,
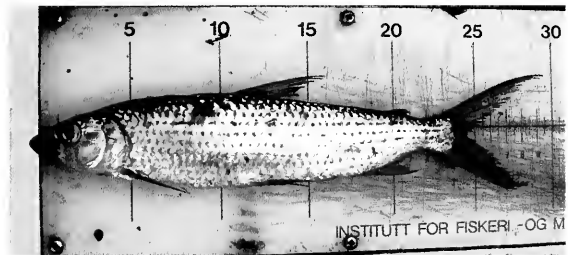Mgaburaka, Rokel/Seli River (Robert Wakeford)

Barbus sacratus, 284 mm SL, above Bumnuna
Falls, Rokel/Seli River (Robert Wakeford)

Varicorhinus wurtzi, 406 mm SL, below Bumbuna
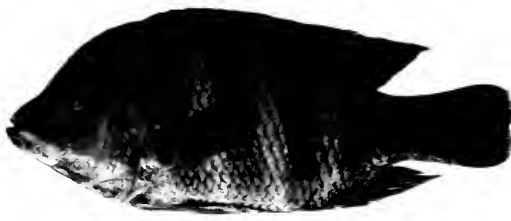Falls, Rokel/Seli River (Robert Wakeford)

Raiamas scarciensis, 239 mmSL, below Bumbuna
Falls, Rokel/Seli River (Robert Wakeford)

Hydrocynus forskalii, 298 mm SL, below Bumbuna
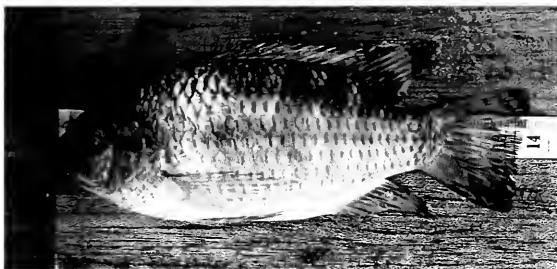Falls, Rokel/Seli River (Robert Wakeford)

PLATE 2

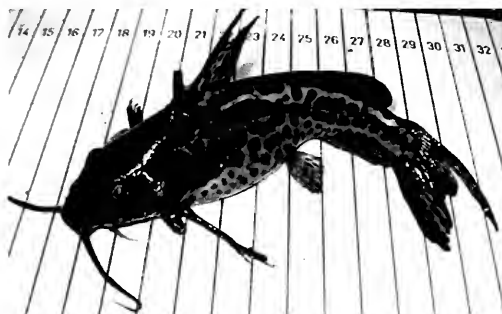*Tilapia buttikoferi*, 279 mm SL, River Taia
(Bernadette McCarton)

Sarotherodon occidentalis, 344 mm SL, breeding
colouration, Rive Taia (Bernadette McCarton)

Tilapia louka, 137 mm SL, above Bumbuna Falls,
Rokel/Seli River (Robert Wakeford)

Tilapia brevimanus, 194 mm SL, Magburaka, Rokel
/ Seli River (Robert Wakeford)

Synodontis waterloti, 158 mm SL, Mabole River
(Robert Arthur)

Synodontis tourei, 222 mm SL, below Bumbuna
Falls, Rokel/Seli River (Robert Wakeford)

Synodontis cf. *filamentosus*, 169 mm SL,
Mgaburaka, Rokel/Seli River (Robert Wakeford)

New species of Indo-Pacific jawfishes (*Opistognathus*: Opistognathidae) from the Western Indian Ocean and Red Sea

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ABSTRACT. Descriptions of six new species of the jawfish genus *Opistognathus* from the Western Indian Ocean are provided: *O. adelus* (South Africa and Madagascar); *O. afer* (Kenya to South Africa); *O. crassus* (Maldive Islands); *O. dipharus* (Red Sea); *O. longinaris* (South Africa); *O. simus* (Cargados Carajos). All of these species are sufficiently distinct that no obvious Indo-West Pacific sister-species are apparent. An identification key and summary table of selected characters are provided for all species of *Opistognathus* known from the Western Indian Ocean.

RÉSUMÉ. Les descriptions de six nouvelles espèces du genre *Opistognathus* de la partie Ouest de l'Océan Indien sont : *O. adelus* de l'Afrique du Sud et du Madagascar ; *O. afer* (du Kenya à l'Afrique du Sud); *O. crassus* (Des îles Moldavies) ; *O. dipharus* (de la Mer rouge) ; *O. longinaris* (Afrique du Sud) ; *O. simus* (Cargados). Toutes ces espèces sont si différentes qu'aucune espèce apparente de la famille soeur trouvée dans la partie Est de l'Océan indien n'est visible. Le mot-clé d'identification et le classement des caractères spécifiques sont donnés pour toutes les espèces *Opistognathus* connues de la partie occidentale de l'océan indien.

INTRODUCTION

The jawfish family Opistognathidae is characterized by prominent upper jaws, large mouths, bulbous eyes, heads that usually lack scales, and a unique pelvic fin arrangement consisting of one spine and five segmented rays, the outer two unbranched and usually relatively thick. All jawfishes orally incubate their eggs and are obligatory burrow dwellers, using their large mouths to excavate and maintain their burrows. Forty-two species of jawfishes from the Indo-West Pacific Ocean (including the Red Sea) are currently recognized as valid with at least 34 others known that lack scientific names. Because of their fossorial behavior and relatively poorly sampled habitats, new species of opistognathids continue to be discovered.

The primary purpose of this publication is to provide descriptions of six new species of *Opistognathus* from the region (Fig. 1), so their scientific names will be available for inclusion in a soon-to-be published book on the coastal fishes of the Western Indian Ocean. Prior to description of *Opistognathus margaretae* (Smith-Vaniz 1983) from southern Africa and Madagascar only two other species of *Opistognathus* Cuvier were known from the Red Sea or Western Indian Ocean: *O. nigromarginatus* Rüppell (1830) and *O. muscatensis* Boulenger (1887). Expanded accounts and illustrations of the latter two species were given by Smith-Vaniz (2009) together with description of a fourth Indian Ocean species, *O. variabilis*, known from the Maldive Islands and Sri Lanka eastward to Palau.

Stalix Jordan and Snyder, another jawfish genus, also occurs in the region and is represented by two species. *Stalix omanensis* Norman (1939), from the Gulf of Oman — known only from the holotype trawled in 73 m, and *S. davidsheni* Klausewitz (1985), represented by two specimens collected in 9-17 m from the Gulf of Aqaba. Both species were redescribed by Smith-Vaniz (1989) and, based on the distributions of the 11 species recognized in that revision (and others subsequently discovered), it is likely that additional species of *Stalix* occur in the Western Indian Ocean. *Stalix* differs from *Opistognathus* and all other fish genera in having the first 5-9 dorsal-fin spines transversely forked distally and the skin covering them forming a broad dorsal hood to accommodate the uniquely shaped spines.

The infraorbital bones are quite different in some species of *Opistognathus* that occupy similar habitats and depth ranges, and thus may prove useful in inferring relationships. Illustrations of the infraorbitals of selected Western Indian Ocean species are given here for comparison (Fig. 2), but a phylogenetic analysis of Indo-Pacific jawfishes is beyond the scope of this study. An identification key and summary of selected characters (Table 1) are provided for all 10 species of *Opistognathus* now known from the Western Indian Ocean to aid in recognition of the new species described herein. Because *O. variabilis* exhibits considerable geographic variation, meristic data for this species are based only on Indian Ocean specimens.
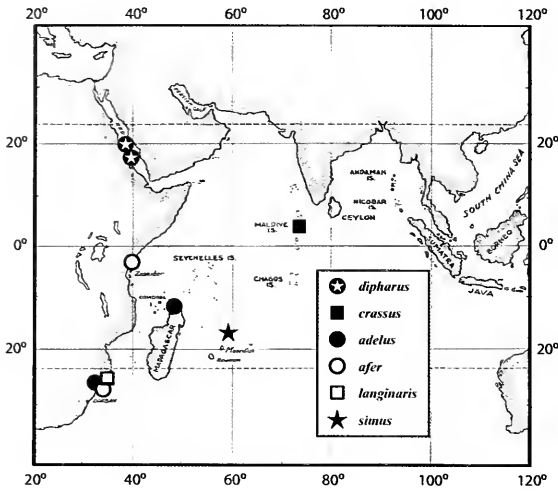
Fig. 1. Known distributions of new species of *Opistognathus* described herein. Collections from closely adjacent localities are represented by single symbols.

Fig. 2. Lateral views of infraorbitals, anterior to the right (3rd infraorbital also rotated in dorsal view), excluding dermosphenotic, in selected species of *Opistognathus*: A, *O. adelus*, SAIAB 39747, 49.6 mm SL, South Africa; B, *O. afer*, SAIAB 7601, 39.1 mm SL, Kenya; C, *O. crassus*, BPBM 32706, 35.5 mm SL, Maldive Islands; D, *O. dipharus*, HUJ E62/3685, 47.2 mm SL, Red Sea; E, *O. longinaris*, SAIAB 39747, 41.0 mm SL, South Africa; F, *O. margaretae*, ANSP 149352, 50.7 mm SL, South Africa; G, *O. muscatensis*, SAIB 7602, 133 SL, Seychelles; H, *O. simus*, ANSP 167418, 49.2 mm SL, Cargados Carajos.

MATERIALS AND METHODS

Abbreviations used for institutional depositories are as follows: Academy of Natural Sciences of Philadelphia (ANSP); Bernice P. Bishop Museum, Honolulu (BPBM); Hebrew University, Jerusalem (HUJ); Royal Ontario Museum, Toronto (ROM); South African Institute of Aquatic Biodiversity, Grahamstown (SAIAB); National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM).

Detailed methods of counts and measurements are given in Smith-Vaniz (2009) and only some that might otherwise be unclear are repeated here. The last two elements in the dorsal and anal fins have their bases in close approximation ('split to base' condition) and were counted as one ray in accord with the general practice of most authors, although the ultimate element has a separate rudimentary pterygiophore or stay. The short, dorsalmost element in the pectoral fin is included in the ray counts. Vertebral counts from radiographs are presented as a formula: precaudal + caudal = total count.When the lateral line ends approximately mid-way between two dorsal-fin elements, the number was rounded and the higher value tabulated in Table 5. The number of oblique scale rows is only an approximation due to the irregular size and arrangement of individual scale rows. Included in this count are all anteroventrally aligned scale rows in a longitudinal series from above the tip of the opercular flap to the base of the caudal fin (cou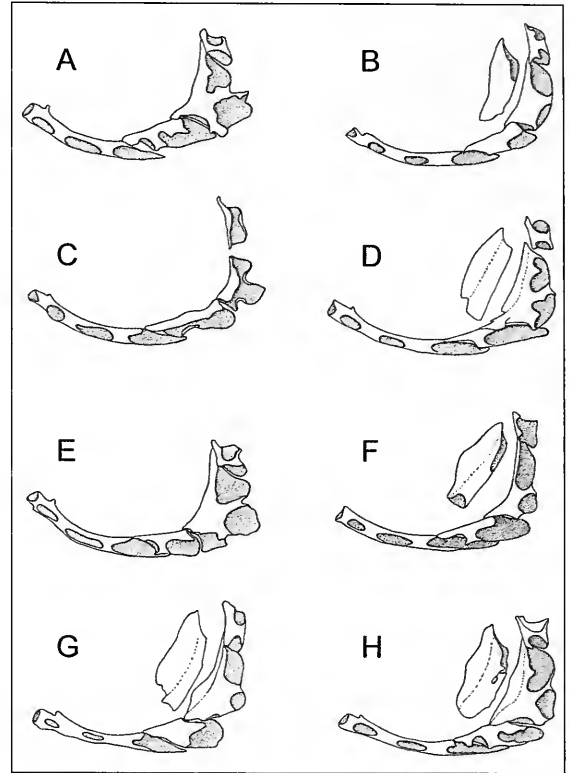nts of posteroventrally aligned scale rows result in lower values). In some cases number of scale rows and gill rakers were counted on both the left and right sides of specimens and recorded separately in the text and Tables 3 and 4. Detection of cephalic sensory pores was facilitated in some specimens by staining with a cyanine blue solution (Saruwatari et al. 1997). Specimen sizes are given as mm standard length (SL), and parenthetical expressions give number of specimens, if more than one, followed by the size range. Cleared and stained specimens are indicated as 'C&S'. In cases where whole C&S specimens were unavailable, the right infraorbital and jawbones were dissected and stained, and drawings of them are shown in reverse to facilitate comparisons with other species whose left bones are illustrated.
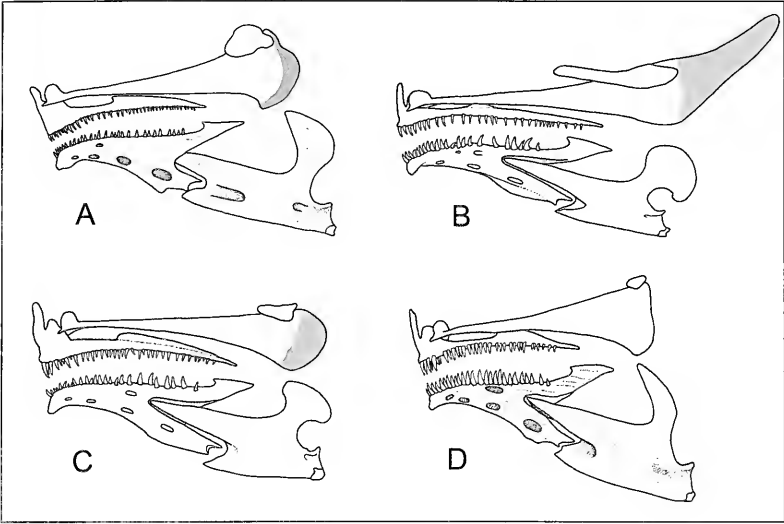
Fig. 3. Upper and lower jaws (thin flexible part of maxilla shaded) in selected species of *Opistognathus*: A, *O. adelus*, SAIAB 39747, female, 49.6 mm SL, South Africa; B, *O. nigromarginatus*, ANSP 143892, female, 122 mm SL, India; C, *O. muscatensis*, SAIAB 7602, male, 133 mm SL, Seychelles; D, *O. margaretae*, ANSP 149352, male, 50.7 mm SL, South Africa.

Table 1. Summary of selected characters in Western Indian Ocean species of *Opistognathus* (exceptional values in parentheses).

Characters	*Opistognathus* species									
	crassus	*afer*	*adelus*	*margaretae*	*dipharus*	*simus*	*longinaris*	*muscatensis*	*nigromarginatus*	*variabilis*
Dorsal fin	XI, 11	XI, 13-14	XI, 13-14	XI, 13-14	XI, 15	XI, 15	X, 20	XI, 15	XI, 14 (15)	X!, 15
Anal fin	II, 10	III, 12-14	III, 13-14	III, 13-14	III, 16	III, 15-16	III, 19	III, 15	III, 14 (15)	III, 15
Caudal vertebrae	16	17-18	17-18	18	19	19	24	19	18	19
Hypural 5 present	yes	no	no	yes	no	no	no	no	no	no
Supraneural bones	2	0	1	1	0	1	0	1	1	1
Total gill rakers	34	22-23	24-25	26-29	28	27-28	23-25	36-44	39-45	31-37
Oblique scale rows	44	58-62	40-41	38-52	63-64	53-62	40-42	103-128	68-95	75-79
Lateral line ends below										
segmented ray	2	2-4	3-4	(3) 4-6	6-7	6	8	(4) 5-7	4-6	4-6
Cirrus on anterior nostril	no	no	yes	yes	yes	yes	yes	no	no	no
Vomerine teeth	no	yes	no	no	no	no	no	no	no	no
Maxilla fimbriate posteriorly	no	no	yes	no	no	no	no	yes (slight)	yes	yes
Under side of upper jaw with										
dark blotch or stripe	no	no	blotch	blotch	blotch	blotch	blotch	no	2 stripes	1 stripe
Area around esophageal opening										
or inside of mouth partly dark	no	yes	no	no	no	no	yes	no	yes	yes
Dorsal fin with ocellus	no	no	no	yes	no	no	no	yes	yes	no
Dorsal-fin spine tips with										
pale, fleshy tabs	yes	yes	no	no	no	no	no	no	no	no

KEY TO SPECIES OF *OPISTOGNATHUS* OF THE WESTERN INDIAN OCEAN

1a. Dorsal fin with ocellated spot between third or fourth and eighth spines followed by two large, irregular, dark blotches that extend onto body; outermost segmented pelvic-fin ray tightly bound to adjacent ray, and interradial membrane not incised distally or only slightly at tip (Persian Gulf, Seychelles and East African coast) .... *O. muscatensis* Boulenger

1b. Colour pattern not as above; outermost segmented pelvic-fin ray not tightly bound to adjacent ray, and interradial membrane distinctly incised distally 2

2a. Posterior end of upper jaw with a flexible lamina (Figs. 3 A-C).. 3
2b. Posterior end of upper jaw rigid, without a flexible lamina (Fig. 3D) 5

3a.   Lower limb and total gill rakers 15 or 16 and 24 or 25, respectively, in adults; body with about 40-44 oblique scale rows; supramaxilla relatively wide and oval-shaped (southern Africa and Madagascar) ... . *O. adelus*, n. sp.

3b.   Lower limb and total gill rakers 20-29 and 31-45, respectively, in adults; body with about 68-95 oblique scale rows; supramaxilla relatively slender and elongate 4

4a.   Dorsal fin with prominent ocellus between spines 4-8; caudal fin usually with a pair of pale basicaudal spots; lower limb gill rakers typically 23-29 (Persian Gulf, Red Sea and western Indian Ocean to South China Sea) ....*O. nigromarginatus* Rüppell

4b.   Dorsal fin without an ocellus; caudal fin without a pair of pale basicaudal spots; lower limb gill rakers 31-37 (Maldive Islands to Palau)..*O. variabilis* Smith-Vaniz

5a.   Oral membrane between dentaries and "tongue" dark brown; tentacle on anterior nostril at least 4 times maximum diameter of posterior nostril; segmented dorsal- and anal-fin rays 20 and 19, respectively; caudal vertebrae 24 (southern Africa) .... *O. longinaris*, n. sp.

5b.   Oral membrane between dentaries and "tongue" pale; tentacle on anterior nostril about 0.5-2.0 times maximum diameter of posterior nostril; segmented dorsal- and anal-fin rays 11-15 and 10-16, respectively; caudal vertebrae 16-18 6

6a.   Segmented dorsal- and anal-fin rays 11 and 10, respectively; spinous dorsal fin with dark blotches interspaced by sharply defined, pale interspaces nearly as wide as blotches; depth at anal-fin origin 26 % SL (Maldive Islands) .... *O. crassus*, n. sp.

6b.   Segmented dorsal- and anal-fin rays 13-15 and 12-16, respectively; colour pattern of dorsal fin not as above; depth at anal-fin origin 15-20 % SL 7

7a.   Dorsal fin with an ocellated spot between 3rd and 5th spines; body usually naked anterior to vertical below last dorsal-fin spine (southern Africa and Madagascar) .... *O. margaretae* Smith-Vaniz

7b.   Dorsal fin without an ocellated spot; body naked anterior to vertical below 5th or 6th dorsal-fin spines 8

8a.   Segmented dorsal- and anal-fin rays 13 or 14 and 12-14, respectively; anterior nostril without a cirrus; dorsal-fin spines moderately stout and straight distally, with slightly swollen fleshy tabs on tips; vomerine teeth 2 or 3; lateral-line terminus below verticals from 2nd to 4th segmented dorsal-fin rays (southern Africa) .... *O. afer*, n. sp.

8b.   Segmented dorsal- and anal-fin rays 15 and 15 or 16, respectively; anterior nostril with a slender cirrus; dorsal-fin spines relatively slender and curved distally with flexible tips lacking swollen fleshy tabs; vomerine teeth absent; lateral-line terminus below verticals from 6th or 7th segmented dorsal-fin rays 9

9a.   Caudal fin with pair of conspicuous basicaudal spots; spinous dorsal fin with a row of pale mid-lateral spots; no supraneural bones (Red Sea) .... *O. dipharus*, n. sp.

9b.   Caudal fin without a pair of conspicuous basicaudal spots; spinous dorsal fin without a row of pale mid-lateral spots; 1 supraneural bone (Carados Carajos) .... *O. simus*, n. sp.

Opistognathus adelus sp. nov.
Obscure jawfish
Figs. 4-6

Holotype. SAIAB 49583, male (47.0), Madagascar, off Nosy Tanga, W coast of Nosy Bé, 13°23′S, 48°11′E, 5-10 m, silty sand, P. C. Heemstra and D. A. Hensley, 7 September 1995.

Paratypes: 4 specimens, 21.0-48.9 mm SL. SAIAB 54745, largest gravid female (3, 21.0-48.9) and USNM 372769, gravid female (46.2), taken with the holotype.

Other material: SAIAB 39747, female (49.6), South Africa, Kwazulu, Kosi mouth area, 26°53′S, 32°55.8′E, dredged in 65 m, R. N. Kilburn, 7 June 1987, R/V Meiring Naude.

DIAGNOSIS. A species of *Opistognathus* with the following combination of characters: upper jaw broadly rounded with a large oval-shaped supramaxilla, and maxilla with a flexible lamina posteriorly; dorsal-fin rays XI, 13 or 14; posterior angle of jaws, including inner lining of maxilla and adjacent membranes with dark blotch; dorsal fin without ocellus or large dark blotches; vomerine teeth absent.

DESCRIPTION. (Counts for holotype given in parentheses if different from any of the other specimens.) Dorsal-fin rays XI, 13 or 14 (14). Anal-fin rays III, 13 or 14 (14). Pectoral-fin rays 18 or 19 (18). Caudal fin: procurrent rays 3-4 + 3-4, segmented rays 8 + 8, middle 13 or 14 branched, total elements 22 or 24; hypural 5 absent. Vertebrae: 10 +17 or 18 (17
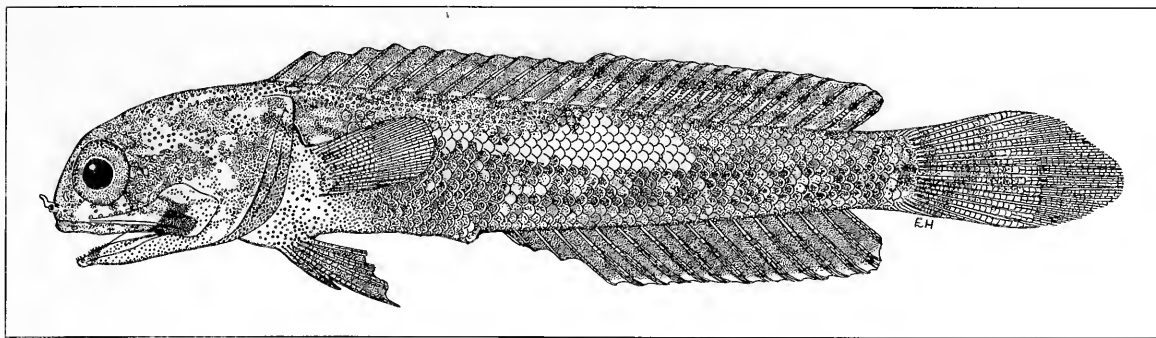
Fig. 4. *Opistognathus adelus*, holotype, SAIAB 49583, male, 47.0 mm SL, Madagascar, west coast of Nosy Be. Drawn by Elaine Heemstra.

Fig. 5. *Opistognathus adelus*, holotype (after preservation in alcohol). Photograph by Richard T. Bryant.

only in South Africa specimen); last rib on vertebra 10; epineurals 10. A single supraneural bone inserted between neural spines 1–2. Gill rakers 9 + 15 or 16 (15), except 6 + 14 in two small juveniles, 21.0–23.0 mm SL.

Scales absent on head and body anterior to vertical from 6th dorsal-fin spine, and from area above and below lateral line, pectoral-fin base and anterior one-third 1of belly. Body with about 40 or 41 oblique scale rows. Lateral-line ends below vertical between 2nd to 4th segmented dorsal-fin rays, total element position 13–15. Lateral-line pores numerous, arranged in multiple series along embedded lateral-line tubes. Cephalic sensory pores relatively numerous (Fig. 6), completely covering nape except for small area adjacent to dorsal-fin origin; dentary pore positions 1–2 with relatively large, single pores, 3rd position with 1–3 (1) pores, 4th with 2–5 (2) pores, 5th with 8–18 (8) pores; all preopercular pore positions with multiple pores.

Anterior nostril slightly closer to posterior nostril than to dorsal margin of upper lip, and with a simple tentacle on posterior rim that when depressed extends slightly beyond orbital margin; length of tentacle about 2 times maximum of diameter of posterior nostril. Dorsal fin very low anteriorly gradually increasing in height posteriorly; profile relatively uniform with slight change in fin height at junction of spinous and segmented rays. Dorsal-fin spines slender and straight or slightly curved distally

with flexible tips; all segmented dorsal- and anal-fin rays branched distally. Outermost segmented pelvic-fin ray not tightly bound to adjacent ray, interradial membrane incised distally. Posterior margin of preopercle distinct with free margin. No papillae on inner surface of lips. Fifth cranial nerve passes under A1β section of adductor mandibulae.

Upper jaw extends 1.0 to 1.2 eye diameters behind posterior margin of orbit; maxilla widest before end, then canted downward and rounded, with flexible lamina posteriorly (Fig. 3A); supramaxilla large, oval-shaped and subterminally positioned. Premaxilla with an outer row of moderate, sharply pointed teeth that become progressively smaller posteriorly; 2 or 3 inner rows of smaller, conical teeth anteriorly, except several on each side of symphysis somewhat enlarged and canted backwards. Dentary with an outer row of moderate conical teeth, largest mid-laterally; 2 or 3 irregular inner rows of smaller conical teeth anteriorly, several slightly canted backwards. Vomerine teeth absent. Infraorbital bones tubular with wide openings for sensory canals (Fig. 2A), 3rd infraorbital relatively robust without suborbital shelf.

Measurements of three paratypes, 46.2–49.6 mm, and the 47.0 mm holotype (in parentheses), as percent of SL: predorsal length 29.8–31.0 (31.3); preanal length 54.6–57.9 (53.8); dorsal-fin base 63.1–73.9 (68.7); anal-fin base 36.5–40.0 (41.3); pelvic-fin length 16.8–18.2 (18.9); caudal-fin length 20.5–21.6

(21.1); depth at anal-fin origin 13.8–14.9 (15.1); caudal-peduncle depth 7.7–8.1 (7.9); head length 29.5–31.4 (31.5); postorbital-head length 20.2–20.6 (20.9); upper-jaw length 18.7–19.9 (21.5); postorbital-jaw length 8.4–10.6 (11.7); orbit diameter 8.7–9.5 (9.7). As percent of head length: postorbital-head length 64.8–68.6 (66.2); upper-jaw length 62.6–63.5 (68.2); postorbital-jaw length 28.3–34.4 (37.2); orbit diameter 29.4–30.3 (30.7).

Preserved colouration of holotype (life colouration unknown): head and body primarily tan, but naked areas of body, including pectoral-fin base, heavily freckled with discrete chromatophores; naked area of body above and beneath pectoral fin with a few pale spots; upper lip with dark bands and inner lining of upper jaw and adjacent membranes with posterior black blotch that is externally visible (Fig. 7A); inside of mouth pale; branchiostegal membranes dark brown and orbital rim with small brown spots; dorsal fin mostly tan but soft portion of fin with a row of faint brown spots centered on each ray below which is a row of slightly larger pale spots, and its base with five evenly spaced faint, dark blotches; pelvic and anal fins dark, the latter with pale margin; caudal fin without bands and with small, narrow, dark blotch (not evident in the illustrations) between pair of indistinct pale basicaudal spots.

In preservation, females differ primarily from male holotype in having paler pelvic fins.

DISTRIBUTION. South Africa and northwest Madagascar (Fig. 1) in 5–65 m.

ETYMOLOGY. The specific epithet is from the Greek *adelos* (dim or obscure), in reference to the uncertain phylogenetic relationships of this jawfish.

REMARKS. The single South African specimen differs from the five Madagascar specimens in having one fewer caudal vertebra and one fewer segmented ray in both the dorsal and anal fins. This specimen is slightly larger than the others and has more dentary pores. The following counts are left and right side values for the 49.6 mm South African specimen followed, in parentheses, by range values for the three largest (46.2–48.9 mm) Madagascar specimens: 3rd dentary position 2/3 (1); 4th position 5/4 (2–4); 5th position 18/16 (8–12). These differences in number of pores are assumed to be within the normal range of variation, especially considering the few available specimens. Specimens from the two localities have essentially identical colour patterns and jaw morphologies and, despite the meristic differences (reductions in numbers of vertebrae and fin rays are often correlated in jawfishes), are here considered to be conspecific. Because of the possibility that two allopatric sister-species are actually represented, the South African specimen is not designated as a paratype.

The combination of an upper jaw with flexible lamina posteriorly and large oval-shaped supramaxilla in *O. adelus* is shared only with *O. iyonis* (Jordan and Thompson 1913), known only

from Japan and Korea, but the two species differ in so many other characters, including very different colour patterns, that a sister-group relationship seems very unlikely.
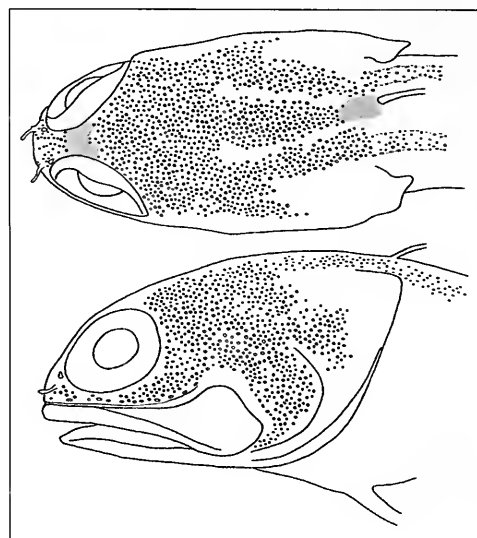

Fig. 6. Cephalic sensory pores of *Opistognathus adelus*, holotype (reversed right side view). Shaded areas indicate damaged regions of head where pores could not be accurately depicted.
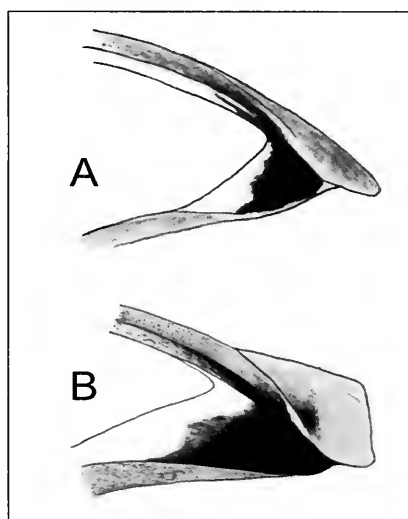

Fig.7. Lateral views of partially rotated left jaws to show dark pigment on inner lining of maxilla and adjacent membranes (dorsal margin of maxilla is a top of figures): A, *Opistognathus adelus*, SAIAB 39747, female, 49.6 mm SL, South Africa; B, *O. simus*, USNM 315659, male, 55.0 mm SL, Cargados Carajos.
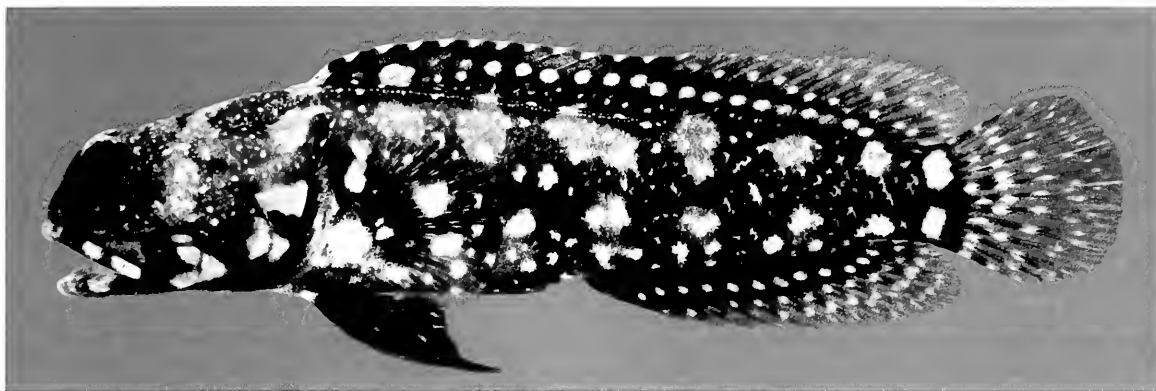
Fig. 8. *Opistognathus afer*, holotype, SAIAB 39994, male, 41.2 mm SL, South Africa, Maputoland Reef (Phillip C. Heemstra).

Fig. 9. *Opistognathus afer*, SAIAB 42789, gravid female, 37.3 mm SL, Mozambique, Ponta Malongane (Phillip C. Heemstra).

Opistognathus afer sp. nov.
African jawfish
Figs. 8–10

Holotype. SAIAB 39994, male (41.2), South Africa, Maputoland Reef, 2 km south of Kosi mouth, 26°54'S, 32°53'E, 31 m, bottom, bedrock, sand and gravel, rotenone, C. Buxton, P.C. Heemstra, W. Holleman, R. Tilney and T. Andrew, 9 August 1992.

Paratypes: 4 specimens, 21.7-41.3 mm SL. **Mozambique**: SAIAB 42789, gravid female (37.3), Ponta Malongane, 26°46'44"S, 32°54'14"E, 22-25 m, P. C. Heemstra, T. Andrew and A. Wood, sta. PCH 95-04, 2 November 1995. **South Africa**: SAIAB 56415, gravid female (41.3) and USNM 368139, gravid female (37.7), Sodwana Bay, 27°32'1"S, 32°41'13"E, 30-32 m, sand and scattered sponges, P.C. Heemstra, D. Polack, S. Polack and J. Dench, sta. KZN FW97-01, 12 August 1997; ROM 72836, female (21.7), ESE of Sodwana Bay, S. of Uniform Reef, 27°30'10"S, 32°42'07"E, 28-30 m, R. Winterbottom et al., 15 May 2001.

Other material: SAIAB 7601, gravid female (39.1), Kenya, Shimoni, 4°39'S, 39°23'E, J.L.B. and M. M. Smith, 21 November 1952.

DIAGNOSIS. A species of *Opistognathus* with the following combination of characters: maxilla rigid, without flexible lamina posteriorly; dorsal-fin rays XI, 13 or 14; body and dorsal fin with one or more horizontal rows or series of pale spots; tips of spines with conspicuously pale fleshy tabs; all dentary-preopercular pore positions with single pores; vomerine teeth 2 or 3.

DESCRIPTION. (Counts for holotype given in parentheses if different from any of the paratypes.) Dorsal-fin rays XI, 13–14 (13). Anal-fin rays III, 12–14 (13). Pectoral-fin rays 19–20 (19). Caudal fin: procurrent rays 5–6 (4) +4–6 (4), segmented rays 8 + 8, middle 13 (12) branched, total elements 25–26 (24); hypural 5 absent. Vertebrae: 10 + 17 or 18 (18 only in Kenya specimen); last rib on vertebra 10; epineurals 12. Supraneural bones absent. Gill rakers 8 + 14–15 (15).
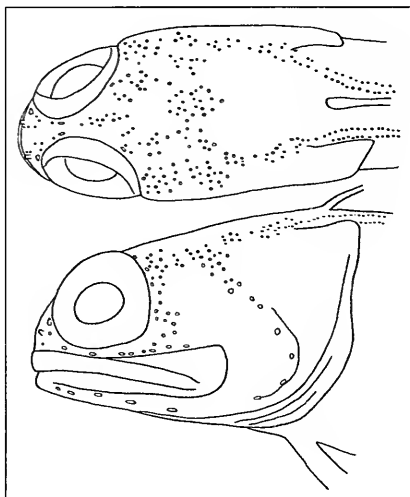
Fig. 10. Cephalic sensory pores of *Opistognathus afer*, holotype (reversed right side view).

Scales absent on head and body anterior to a vertical from 3rd to 4th dorsal-fin spine, and from area above lateral line, pectoral-fin base, breast and anterior half of abdomen. Body with about 58–62 oblique scale rows in longitudinal series (scale rows very irregular anteriorly making it difficult to make precise counts). Lateral line ends below verticals between 2nd to 4th segmented dorsal-fin ray, total element position 13–14.5 (14). Lateral-line pores sparse, mostly arranged in a single row above and below embedded lateral-line tubes. Cephalic sensory pores relatively sparse (Fig. 10); all dentary-preopercular pore positions with single pores.

Anterior nostril positioned slightly closer to posterior nostril than to dorsal margin of upper lip, and consisting of a moderate tube that when depressed does not reach or just reaches margin of posterior nostril; height of tube slightly longer than maximum diameter of posterior nostril. Dorsal fin moderately low, profile of fin with slight increase in height at junction of spinous and segmented rays, profile of fin gradually increasing in height posteriorly. Dorsal-fin spines moderately stout, straight and pungent distally, with slightly swollen fleshy tabs on tips; all segmented dorsal- and anal-fin rays usually branched distally (first 2 anal rays unbranched in smallest paratype). Outermost segmented pelvic-fin ray not tightly bound to adjacent ray, interradial membrane incised distally. Posterior margin of preopercle distinct, with slight free margin. No papillae on inner surface of lips. Fifth cranial nerve passes over A1β section of adductor mandibulae.

Upper jaw extends about 0.5–0.75 eye diameters behind posterior margin of orbit; maxilla widest at end and truncate, without flexible lamina posteriorly; supramaxilla present, relatively small and terminally positioned. Premaxilla with outer row of moderately small, conical teeth that become progressively smaller posteriorly; 1 or 2 irregular rows of teeth behind outer row anteriorly, including 3 or 4 slightly enlarged teeth on each side of symphysis that are almost horizontally aligned. Dentary teeth similar to those of premaxilla except 1–3 rows of teeth behind outer row on anterior half of each dentary, those in innermost row canted backwards. Vomerine teeth 2 or 3. Infraorbital bones tubular with wide openings for sensory canals (Fig. 2B), 3rd infraorbital only slightly robust and without suborbital shelf.

Measurements of four paratypes, 37.3–41.3 mm, and the 42.1 mm holotype (in parentheses), as percent of SL: predorsal length 32.7–35.9 (33.7); preanal length 58.6–60.5 (59.6); dorsal-fin base 61.4–69.4 (64.6); anal-fin base 31.6–34.6 (33.0); pelvic-fin length 23.9–26.1 (24.0); caudal-fin length 23.2–23.4 (23.5); depth at anal-fin origin 16.2–20.1 (19.4); caudal-peduncle depth 9.6–10.9 (10.4); head length 9.9–10.9 (10.4); postorbital-head length 21.6–22.8 (23.5); upper-jaw length 17.4–19.8 (20.3); postorbital-jaw length 5.5–6.5 (7.8); orbit diameter 10.9–11.7 (10.2). As percent of head length: postorbital-head length 62.0–63.2 (63.6); upper-jaw length 50.9–54.0 (54.8); postorbital-jaw length 15.9–18.4 (21.0); orbit diameter 31.7–33.0 (27.5).

Preserved colouration of male holotype: background colour of head and body brown, speckled with random small white spots and larger ones arranged in distinct patterns; body with two rows of six large, irregular, pale spots, the upper row slightly below dorsal fin extending from above pectoral fin to end of fin and the other one from beneath lower part of pectoral fin to rear of anal fin; large pale spot also on lower half of pectoral-fin base and a smaller one just above upper base of fin; head with prominent pale spots behind end of upper jaw, on angle of preopercle, on opercle opposite preopercular spot, and a larger one across middle of opercle; upper lip with alternating brown and white bands, and middle of upper jaw with large brown band bordered posteriorly by a double white spot constricted in its middle; under side of upper jaw pale, except membrane connecting dorsal margin of maxilla to head and immediately adjacent internal sides of mouth brown; iris dark brown; dorsal and anal fins dark brown with several rows of white spots, the row nearest base of fin with the largest spots; spinous dorsal fin also with an isolated larger white spot anteriorly on spines 3–5 that touches dorsum; all spine tips with white fleshy tabs; caudal fin dark brown anteriorly with a pair of basicaudal white spots, otherwise fin light brown with 4 or 5 irregular bands of small white spots; pelvic fin very dark.

Preserved colouration of females: pale spots on head, body and caudal fin essentially the same as in males (except Mozambique females with lower row of body spots with six or seven large white spots instead of 6); dorsal fin with dark area above ventral row of white spots more intense and appearing as a black submarginal stripe; anal fin with series of unevenly distributed white spots along base of fin superimposed on a dark basal stripe with remainder

of fin mostly pale except for an irregular row of dark diagonal stripes; pelvic fin partially pale with dark bands.

Colour of holotype (Fig. 8) when fresh: head and body various shades of yellowish-tan to dark brown superimposed with pale yellow or white spots; dark blotches or bands on lips and upper jaw dark brown; lower part of cheek, opercle and gill membranes also dark brown; iris dark brown; all spots on fins are white; except for these spots, the dorsal and anal fins are dark brown with distal two thirds of soft portion of fins much lighter brown; caudal fin dark brown only in area around pair of white basicaudal spots; pelvic fin essentially black.

Mature females (Fig. 9) differ from males primarily in having background colour of head and body brownish-purple; submarginal stripe in the dorsal fin black; shafts of segmented- dorsal and caudal rays yellowish, broken by three small white spots variably positioned along each shaft; iris reddish. Colour observations were available for only one individual of each sex so some differences in life colouration (but not the colour pattern - see above) possibly reflect only individual variation.

Distribution. Coastal areas from Kenya to South Africa (Fig. 1) in 22–32 m.

Etymology. The specific epithet is from the Latin *afer* (African), refers to the type locality. The name is treated as a noun in apposition.

Remarks. Because the Kenyan specimen, tentatively identified as *O. afer*, differs from the others in having one additional caudal vertebra (and its colour pattern is poorly preserved), it is not designated as a paratype. However, I believe it is premature to recognize this single specimen as a different new species. Additional material is required for confirmation of the taxonomic status of the Kenyan population. The large distribution gap between the Kenyan and Mozambique localities could be only a collecting artifact as jawfishes are difficult to sample, exacerbated by their fossorial habits, and much of this area of the African coast is poorly surveyed.

No other species of jawfish has such a distinctive pattern of pale head and body spots as *Opisthognathus afer*. Other species of *Opisthognathus* with maxilla that are rigid without flexible lamina posteriorly also differ from *O. afer* either in having only 2 anal-fin spines (most species) or have more segmented dorsal- and anal-fin rays and caudal vertebrae, except *O. margaretae* and *O. rosenbergii* (Bleeker) which differ in having extremely numerous cephalic sensory pores, dorsal fins with prominent ocelli and more total gillraker (26-35 vs. 22 or 23).

Opistognathus crassus sp. nov.
Stout jawfish
Figs. 11–13

Opistognathus sp. Randall and Anderson, 1993: 36 (listed in checklist of Maldive Islands fishes).

Holotype (only known specimen): BPBM 32706, male (35.5), Maldive Islands, Ari Atoll, reef N. of Bathala Islands, E. side, 35 m, rubble bottom, rotenone, J.E. Randall and M. Shiham Adam, 6 March 1988.

Diagnosis. A species of *Opisthognathus* with the following combination of characters: maxilla rigid without flexible lamina posteriorly; dorsal-fin rays XI, 11; anal-fin rays II, 10; tips of dorsal-fin spines conspicuously pale; dorsum with row of 5 dark blotches, some of which extend distinctly onto dorsal fin; last blotch on dorsal fin much narrower than anterior blotches.

Description. Dorsal-fin rays XI, 11. Anal-fin rays II, 10. Pectoral-fin rays 19. Caudal fin: procurrent rays 4 + 4, segmented rays 8 + 8, middle 12 branched, total elements 24; hypural 5 present. Vertebrae: 10 + 16; last rib on vertebra 10; epineurals 14. Two supraneural bones, 1st supraneural inserted anterior to 1st neural spine, the 2nd between neural spines 1–2. Gill rakers 11 + 23.

Scales absent on head, nape, area above lateral line, and breast; a few deciduous scales present on pectoral-fin base. Body with about 44 oblique scale rows in longitudinal series. Lateral-line ends below vertical from 2nd segmented dorsal-fin ray, total element position 13. Lateral-line pores mostly arranged in an irregular series along embedded lateral-line tubes. Cephalic sensory pores relatively numerous (Fig. 13); dentary pore positions 1–4 with single pores, 5th position bipored; most preopercular pore positions bipored.

Anterior nostril about mid-way between posterior nostril and dorsal margin of upper lip, consisting of a short tube that when depressed just reaches anterior margin of posterior nostril; height of tube shorter than maximum diameter of posterior nostril. Dorsal fin moderately high, gradually increasing in height to about middle of spinous dorsal fin; profile with slight increase in height at origin of segmented rays. Dorsal-fin spines moderately stout, straight and with pungent tips; all segmented dorsal-fin rays and all except 1st anal-fin ray branched distally. Outermost segmented pelvic-fin ray not tightly bound to adjacent ray, interradial membrane incised distally. Posterior margin of preopercle indistinct, without free margin. No papillae on inner surface of lips. Fifth cranial nerve passes under A1β section of adductor mandibulae.

Upper jaw extends about half eye diameter behind posterior margin of orbit; maxilla widest at end and truncate, without flexible lamina posteriorly; supramaxilla present, small and terminally positioned. Premaxilla with an outer row of widely spaced conical teeth which become smaller
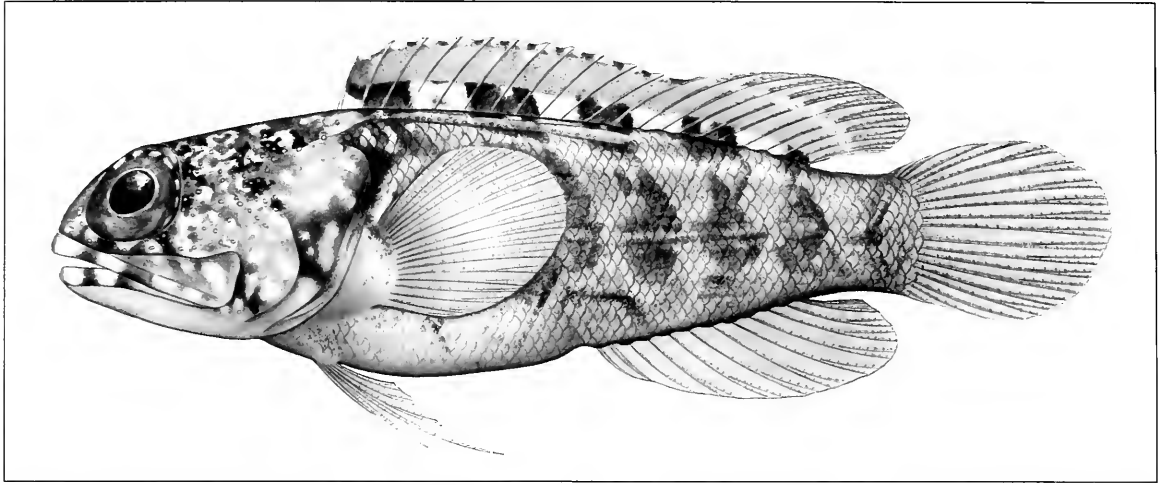
Fig. 11. *Opistognathus crassus*, holotype, BPBM 32706, male, 35.5 mm SL, Maldive Islands, Ari Atoll. (Drawn by Tracy D. Pedersen).
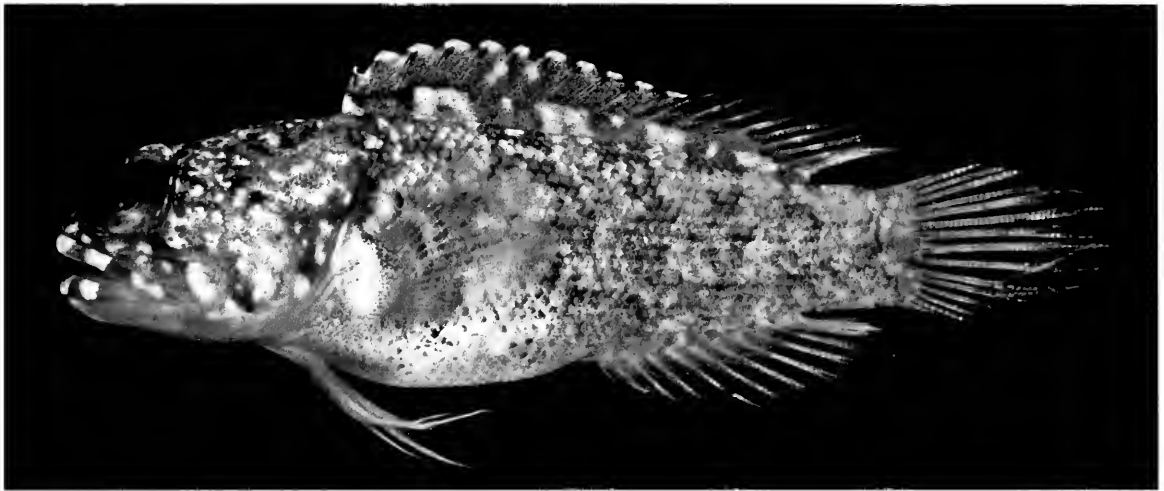

Fig.12. *Opistognathus crassus*, holotype (John E. Randall).

and more closely spaced posteriorly; 2 inner rows of anterior teeth, those in 1st row much smaller than adjacent outer teeth and innermost teeth increasing in size toward symphysis where 2 or 3 enlarged teeth on each side are canted backwards. Dentary with an outer row of conical teeth, all about the same size and slightly smaller than those of premaxilla; 1–3 inner rows of conical teeth anteriorly, those in innermost row mostly hooked or canted backwards. Vomerine teeth absent. Infraorbital bones relatively slender and open laterally, except for tubular 1st infraorbital (Fig. 2C); 3rd infraorbital somewhat T-shaped with the longest arm projecting posteriorly and without suborbital shelf.

Measurements of the 35.5 mm holotype, as percent of SL: predorsal length 37.9; preanal length 67.0; dorsal-fin base 57.3; anal-fin base 25.5; pelvic-fin length 31.0; caudal-fin length 29.0; depth at anal-fin origin 26.0; caudal-peduncle depth 15.3; head length 38.7; postorbital-head length 22.4; upper-jaw length 23.7; postorbital-jaw length 6.8; orbit diameter 13.4. As percent of head length: postorbital-head length 57.8; upper-jaw length 61.1; postorbital-jaw length 17.4; orbit diameter 34.5.

Preserved colouration of holotype: body primarily light brown interspersed with white on some scales, but mostly white on belly and pectoral-fin base; areas between some body scale rows appear as series of faint narrow brown stripes; head scattered with irregular white spots and a few small dark spots; lips tan with several broad white bands and upper jaw with diagonal white spot; inside of mouth and upper jaw uniformly pale; proximal half of dorsal fin with five evenly spaced, dark, basal blotches (the last blotch much smaller than the others), first blotch (between spines 1–4) with ventral white spot between spines 1–2 and all blotches alternating with sharply defined pale areas nearly as wide as the blotches; blotches 2–4 with small pale spot centered on distal margin; remainder of dorsal fin without
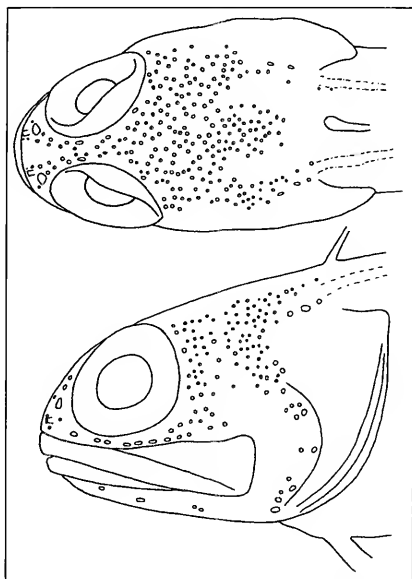
Fig. 13. Cephalic sensory pores (lateral line pores not shown) of *Opisthognathus crassus*, holotype.

conspicuous markings except spine tips with white fleshy tabs; other fins uniformly pale.

Colour of holotype when fresh (Fig. 12): background colour of head and body primarily tan superimposed with irregular white spots and blotches; iris chestnut. Because the fresh holotype was photographed on a black background, some of the more translucent areas of the fins appear darker than they actually are.

DISTRIBUTION. Known only from Ari Atoll, Maldive Islands (Fig. 1) in 35 m.

ETYMOLOGY. The specific epithet is from the Latin *crassus* (thick, fat or stout), in reference to the general appearance of this species.

REMARKS. *Opistognathus crassus* appears to be closely allied to a triad of disjunctly distributed Indo-West Pacific species (undescribed) that share with it the combination of low meristic values, two supraneural bones, nearly identical infraorbital bones and cephalic pore patterns, stiff dorsal-fin spines tipped with pale fleshy tabs, relatively robust bodies, and colour patterns that include dark blotches along the base of the dorsal fin. The colour pattern of *O. crassus* readily distinguishes it from these allopatric species, especially the relative widths of the dark dorsal-fin blotches and the sharply defined pale interspaces between them.

Opistognathus dipharus sp. nov.
Tail beacon jawfish
Figs. 14 & 15

Opisthognathus [sic] *muscatensis* (non Boulenger). Dor, 1970:22 (brief descr.; Red Sea).

Holotype. (only known specimen): HUJ 16975, male (47.2), southern Red Sea, Dahlak Archipelago, Um-Aabak, depth not recorded but collected while snorkeling hence probably ≤ 3 m, H. Steinitz, 6 April 1962.

DIAGNOSIS. A species of *Opistognathus* with the following combination of characters: maxilla rigid without flexible lamina posteriorly; dorsal-fin rays XI, 15; anal-fin rays III, 16; base of caudal fin with pair of conspicuous pale oval spots.

DESCRIPTION. Dorsal-fin rays XI, 15. Anal-fin rays III, 16. Pectoral-fin rays 19. Caudal fin: procurrent rays 5 + 4, segmented rays 8 + 8, middle 12 branched, total elements 25; hypural 5 absent. Vertebrae: 10 + 19; last rib on vertebra 10; epineurals 10. Supraneural bones absent. Gill rakers 10 + 18.

Scales absent from head, nape and body anterior to a vertical from 5th dorsal-fin spine, area above lateral line, pectoral-fin base, breast and anterior
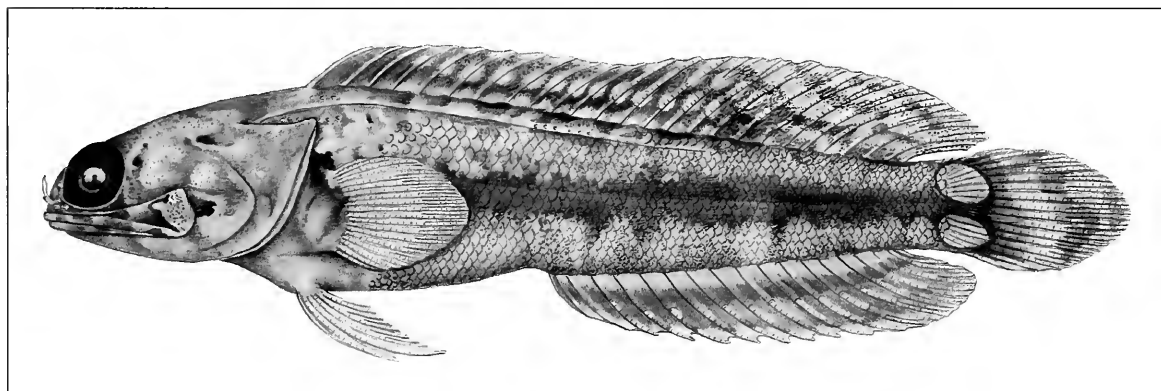

Fig. 14. *Opistognathus dipharus*, holotype, HUJ E62/3685, male, 47.2 mm SL, Dahlak Archipelago, Red Sea. (Drawn by Jack R. Schroeder).
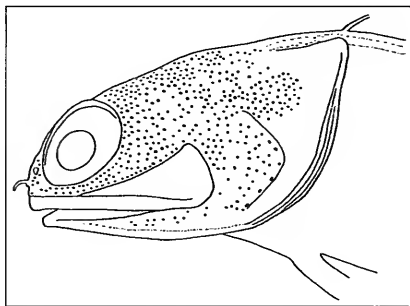
Fig. 15. Cephalic sensory pores (lateral line pores not shown) of *Opistognathus dipharus*, holotype.

one-third of abdomen. Body with about 63 or 64 oblique scale rows in longitudinal series. Lateral-line ends below verticals between 6th and 7th segmented dorsal-fin rays, total element position 17 or 17.5 (left/ right sides). Lateral-line pores numerous, arranged in multiple series above and below embedded lateral-line tubes. Cephalic sensory pores numerous (Fig. 15), completely covering most of head, including entire predorsal area except small area immediately adjacent to dorsal-fin origin; dentary pore positions 1–2 with relatively large single pores, 3rd position with 3/3 pores, 4th with 5/6 pores, and 5th with 11/12 pores.

Anterior nostril distinctly closer to posterior nostril than to dorsal margin of upper lip, with simple, flattened tentacle on posterior rim that when depressed reaches margin of orbit; length of tentacle about 3.0 times maximum diameter of posterior nostril. Dorsal fin moderately low anteriorly gradually increasing in height posteriorly; profile relatively uniform with only slight change in fin height at junction of spinous and segmented rays. Dorsal-fin spines relatively slender and curved distally with flexible tips; all segmented dorsal- and anal-fin rays branched distally. Outermost segmented pelvic-fin ray not tightly bound to adjacent ray, interradial membrane incised distally. Posterior margin of preopercle indistinct, without free margin. No papillae on inner surface of lips. Fifth cranial nerve passes under A1β section of adductor mandibulae.

Upper jaw extends 0.9 eye diameters behind posterior margin of orbit; maxilla widest at end and truncate, without flexible lamina posteriorly; supramaxilla present, small and terminally positioned. Premaxilla with moderate, sharply pointed, conical teeth in outer row that become progressively smaller and more closely spaced posteriorly; 2–3 irregular inner rows of much smaller teeth anteriorly, except several somewhat enlarged teeth on each side of symphysis. Dentary with outer row of conical teeth, largest mid-laterally; 2 or 3 inner rows of slightly smaller teeth anteriorly, except several enlarged teeth in innermost row on each side of symphysis. Vomerine teeth absent. Infraorbital bones tubular with wide openings for sensory canals (Fig. 2D), 3rd infraorbital relatively robust with moderate suborbital shelf.

Measurements of the 47.2 mm male holotype, as percent of SL: predorsal length 31.8; preanal length 53.5; dorsal-fin base 70.6; anal-fin base 40.5; pelvic-fin length 19.2; caudal-fin length 21.0; depth at anal-fin origin 16.3; caudal-peduncle depth 9.2; head length 32.4; postorbital-head length 21.7; upper-jaw length 18.1; postorbital-jaw length 8.2; orbit diameter 9.1. As percent of head length: postorbital-head length 67.0; upper-jaw length 55.9; postorbital-jaw length 25.2; orbit diameter 28.1.

Preserved colouration of holotype: most prominent feature is pair of oval-shaped, pale basicaudal spots superimposed against dark background, remainder of caudal fin light brown with indistinct pale bands; head and body various shades of brown, the latter with darker mid-lateral stripe with irregular margins; both lips with dark bands; inner lining of upper jaw and adjacent membranes with posterior black blotch externally visible, remainder of inside of mouth pale except for distinctly brown area next to jaws that extends to beneath middle of orbit; lateral side of posterior end of upper jaw pale, but with adjacent anterior dark blotch and another on cheek that touches margin of jaw; dorsal fin dusky with series of mid-lateral pale spots (about diameter of pupil) present on most spines and anterior soft rays, followed by several narrow, dark, diagonal bands on posterior portion of fin; anal fin with two dusky stripes, the ventral most best developed; pelvic fin with distal half of outer two rays and interradial membrane pale with remainder of fin brown.

Based on a colour slide of an individual from the Suakin Archipelago (see below), in life the head is tan with the darker markings on upper jaw and cheek rich brown.

DISTRIBUTION. Known only from the southern Red Sea. In addition to the Dahlak Archipelago type locality (16°N, 40°E), this jawfish was photographed by J. E. Randall at Masamirit (18°50′N, 38°46′E), Southern Suakin Archipelago. A single individual was observed in a cove at a depth of 23 m with its head slightly protruding from its burrow. Although collection was unsuccessful, the jaw shape and colour pattern of the head of this jawfish agrees well with the holotype.

ETYMOLOGY. The specific epithet is from the Greek *di* (two, double) and *pharos* (beacon), and refers to the pair of conspicuous pale basicaudal spots against a dark background that characterize this species.

REMARKS. This species is perhaps most closely related to the Indian Ocean *Opistognathus simus*. No trenchant meristic or morphometric differences were found between the two species and they are best distinguished by the basicaudal spots.

Opistognathus longinaris sp. nov.
Long nostril jawfish
Fig. 16

Holotype. (only known specimen): SAIAB 40331, undetermined sex (41.0), South Africa, kwaZulu-Natal, Kosi mouth area, 26°53' S, 32°55.8' E, dredged in 65 m, R. N. Kilburn, 7 June 1987, R/V Meiring Naude.

DIAGNOSIS. A species of *Opistognathus* with the following combination of characters: maxilla rigid without flexible lamina posteriorly; dorsal-fin rays X, 20; tentacle on anterior nostril at least 4 times maximum diameter of posterior nostril; oral membrane between dentaries and 'tongue' dark brown.

DESCRIPTION. Dorsal-fin rays X, 20. Anal-fin rays III, 19. Pectoral-fin rays 19. Caudal fin: procurrent rays 5 + 4, segmented rays 8 + 8, middle 12 branched, total elements 25; hypural 5 absent. Vertebrae: 10 + 24; last rib on vertebra 10; epineurals 11. Supraneural bones absent. Gill rakers 8–9 + 15–16 = 23 or 25.

Scales absent on head and body anterior to vertical from 5th dorsal-fin spine, area above and below lateral line, pectoral-fin base and anterior one-third of belly. Body with about 40-42 oblique scale rows in longitudinal series. Lateral line ends below vertical from 8th (right side, left side damaged) segmented dorsal-fin ray, total element position 18. Lateral-line pores numerous, arranged in multiple series along embedded lateral-line tubes. Cephalic sensory pores relatively numerous, completely covering nape; dentary pore positions 1–3 with relatively large single pores, 4th position with 5/5 pores, 5th with 15/15 pores; all preopercular pore positions with multiple pores.

Anterior nostril distinctly closer to posterior nostril than to dorsal margin of upper lip, and with simple tentacle on posterior rim that when depressed extends well beyond orbital margin; length of tentacle at least 4 times maximum diameter of posterior nostril. Dorsal fin moderately low anteriorly gradually increasing in height posteriorly; profile relatively uniform with slight change in fin height at junction of spinous and segmented rays. Dorsal-fin spines slender and straight or slightly curved distally with flexible tips; all segmented dorsal- and anal-fin rays branched distally. Outermost segmented pelvic-fin ray not tightly bound to adjacent ray, interradial membrane incised distally. Posterior margin of preopercle distinct with free margin. No papillae on inner surface of lips. Fifth cranial nerve passes under A1β section of adductor mandibulae.

Upper jaw extends about 0.65 eye diameters behind posterior margin of orbit; maxilla widest before end and truncate, without a flexible lamina posteriorly; supramaxilla relatively small and terminally positioned. Premaxilla and dentary with an outer row of relatively small conical teeth followed anteriorly by an inner, irregular row of 2 or 3 teeth. Vomerine teeth absent. Infraorbital bones tubular with wide openings for sensory canals (Fig. 2E), 3rd infraorbital robust and without suborbital shelf.

Measurements of the 41.0 mm holotype, as percent of SL: predorsal length 28.8; preanal length 52.4; dorsal-fin base 67.3; anal-fin base 41.0; pelvic-fin length 18.0; caudal-fin length 22.7; depth at anal-fin origin 13.4; caudal-peduncle depth 7.1; head length 32.0; postorbital-head length 21.1; upper-jaw length 16.3; postorbital-jaw length 6.0; orbit diameter 9.1. As percent of head length: postorbital-head length 66.0; upper-jaw length 51.1; postorbital-jaw length 18.7; orbit diameter 28.6.

Preserved colouration (life colouration unknown): head and body brown with several pale spots along posterior margin of opercle and a pale spot, slightly smaller than pupil diameter, on lower pectoral-fin base and another slightly smaller pale spot at upper margin of pectoral fin; nasal tentacle peppered with large melanophores; inner lining of upper jaw and adjacent membranes with posterior black blotch externally visible; oral membrane from inner margin of dentaries dark brown, remainder
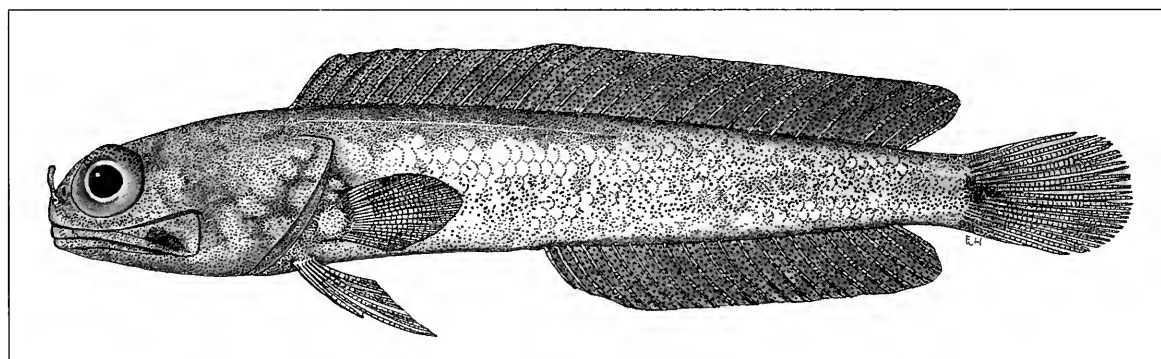

Fig. 16. *Opistognathus longinaris*, holotype, SAIAB 39747, ? male, 41.0 mm SL, South Africa, Kosi mouth area; based in part on camera lucida drawings of right side of head (reversed) and pectoral-fin base pigmentation (left side). (Drawn by Elaine Heemstra).

of inside of mouth pale; pelvic, dorsal and anal fins uniformly dark brown; caudal fin brown but with darker wedge-shaped basicaudal blotch.

DISTRIBUTION. Known only from off kwaZulu-Natal, South Africa (Fig. 1); the only known specimen was dredged in 65 m.

ETYMOLOGY. A combination of the Latin *longus* (long) and *naris* (nostril) in reference to the length of the nasal tentacle.

REMARKS. The only other jawfish that has the inside of the mouth between the dentaries and 'tongue' brown is *Opistognathus jacksonensis* Macleay, an eastern Australia endemic, but it differs from *O. longinaris* most notably in having vomerine teeth, palmate nasal flap, modertaely short and stout dorsal-fin spines, four fewer caudal vertebrae; II versus III anal-fin spines, different distribution and number of body scales; and distinctive colour pattern.
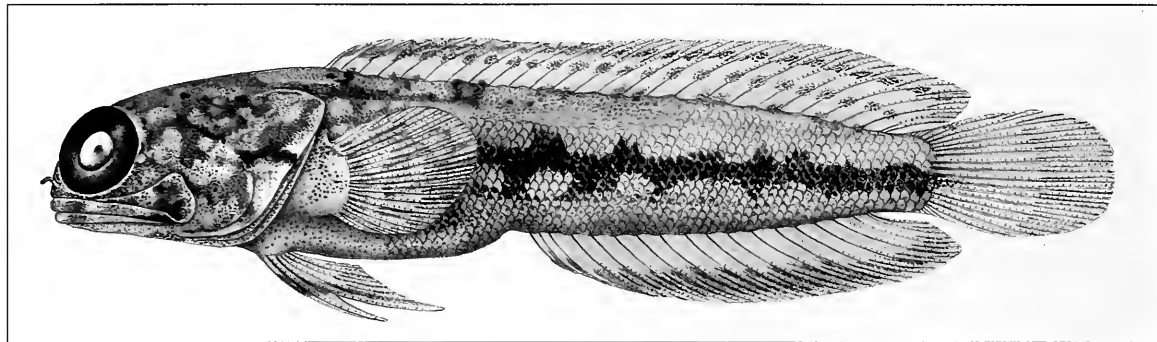
Fig. 17. *Opistognathus simus*, holotype, USNM 315658, female, 66.4 mm SL, Cargados Carajos (= St. Brandon's Shoals). (Drawn by Jack R. Schroeder).

Opistognathus simus sp. nov.
Cargados jawfish
Fig. 17

Holotype. USNM 315658, female (66.4), western Indian Ocean, Cargados Carajos (St. Brandon Shoals), ca. 3.2 km E. of Raphael Island, ca. 16°20'S, 59°38.5'E, 0.2–1.3 m, rotenone, V.G. Springer, C.L. Smith and T.H. Fraser, 3 April 1976, Sta. 76-7.

Paratypes: USNM 315659, male (55.0) and ANSP 167418, female (49.2), same data as holotype.

DIAGNOSIS. A species of *Opistognathus* with the following combination of characters: rigid maxilla without flexible lamina posteriorly; dorsal-fin rays XI, 15; body with about 53–62 oblique scale rows in longitudinal series; scales absent anterolaterally forward of verticals from 5th or 6th segmented dorsal-fin rays; caudal fin without a pair of pale basicaudal spots; vomerine teeth absent.

DESCRIPTION. Dorsal-fin rays XI, 15. Anal-fin rays III, 15 or 16. Pectoral-fin rays 20 or 21. Caudal fin: procurrent rays 5–6 + 4–5, segmented rays 8 + 8, middle 14 branched, total elements 25 or 27; hypural 5 absent. Vertebrae: 10 + 19; last rib on vertebra 10; epineurals 12 or 13. One supraneural bone, inserted between neural spines 1–2. Gill rakers 10 + 17–18.

Scales absent on head, nape and body anterior to verticals from 5th or 6th dorsal-fin spines, area above lateral line, pectoral-fin base, breast and

anterior one-third of abdomen. Body with about 53–62 oblique scale rows in longitudinal series. Lateral-line ends below vertical from 6th segmented dorsal-fin ray, total element position 17. Lateral-line pores numerous, arranged in multiple series above and below embedded lateral-line tubes. Cephalic sensory pores numerous, completely covering most of head, including entire predorsal area except small area immediately adjacent to dorsal-fin origin; dentary pore positions 1–3 with relatively large single pores, 4th position with 3–5 pores, 5th with 8–12 pores.

Anterior nostril distinctly closer to posterior nostril than to dorsal margin of upper lip, and with a simple, flattened tentacle on posterior rim that when depressed reaches margin of orbit; length of tentacle about 1.5 to 2.0 times maximum of diameter of posterior nostril. Dorsal fin moderately low anteriorly gradually increasing in height posteriorly; profile relatively uniform with only slight change in fin height at junction of spinous and segmented rays. Dorsal-fin spines relatively slender and curved distally with flexible tips; all segmented dorsal- and anal-fin rays branched distally. Outermost segmented pelvic-fin ray not tightly bound to adjacent ray, interradial membrane incised distally. Posterior margin of preopercle indistinct, without free margin. No papillae on inner surface of lips. Fifth cranial nerve passes under A1β section of adductor mandibulae.

Upper jaw extends 0.6 to 0.7 eye diameters behind posterior margin of orbit; maxilla widest at end and truncate, without flexible lamina posteriorly; supramaxilla present, small and terminally

positioned. Premaxilla with moderate, sharply pointed, conical teeth in outer row that become progressively smaller and more closely spaced posteriorly; 2–3 irregular inner rows of much smaller teeth anteriorly, except several somewhat enlarged teeth on each side of symphysis. Dentary with outer row of conical teeth, largest mid-laterally; 2 or 3 inner rows of slightly smaller teeth anteriorly, except 3 or 4 teeth in innermost row on each side of symphysis somewhat enlarged but not canted backwards. Vomerine teeth absent. Infraorbital bones tubular with wide openings for sensory canals (Fig. 2H), 3rd infraorbital robust with moderate suborbital shelf.

Measurements of two paratypes, 49.2–55.0 mm, and the 66.4 mm holotype (in parentheses), as percent of SL: predorsal length 32.0, 32.0 (32.1); preanal length 55.5–57.3 (58.6); dorsal-fin base 70.6–71.5 (67.3); anal-fin base 38.6–41.1 (39.8); pelvic-fin length 20.2–21.5 (19.6); caudal-fin length 21.2–21.3 (20.0) (20.0); depth at anal-fin origin 14.6–15.1 (15.4); caudal-peduncle depth 7.8–8.2 (7.9); head length 32.6–34.2 (32.2); postorbital-head length 22.0–22.4 (20.5); upper-jaw length 17.8–18.5 (18.1); postorbital-jaw length 6.1–7.6 (7.1); orbit diameter 10.2–10.4 (9.6). As percent of head length: postorbital-head length 65.3–67.6 (63.6); upper-jaw length 54.0–54.8 (56.1); postorbital-jaw length 17.8–23.2 (22.0); orbit diameter 29.7–31.8 (29.9).

Preserved colouration (life colouration unknown): head and body various shades of brown; head mottled with several indistinct pale spots and a few scattered dark specks; lips with faint bands and inner lining of upper jaw and adjacent membranes with posterior black blotch externally visible (Fig. 7B); inside of mouth pale; body with irregular dark, mid-lateral stripe bordered above and below by adjacent series of faint large pale spots and about 7-9 small, pale brown spots evenly spaced along base of dorsal fin; dorsal fin pale except for narrow submarginal stripe below which is another series of small, dusky spots on spines and rays extending from distal third of fin anteriorly to middle of fin posteriorly; other fins pale except anal fin with about distal third of fin dusky.

DISTRIBUTION. Known only from Cargados Carajos [= St. Brandon Shoals] (Fig. 1) in about 1 m depth.

ETYMOLOGY. The specific epithet, from the Latin *simus* (pugnosed), refers to the blunt snout.

ACKNOWLEDGMENTS

Table 2. Frequency distribution of fin-ray counts and caudal vertebrae in selected Indo-Pacific species of *Opistognathus*.

Species	Dorsal-fin spines and rays X	XI	11	12	13	14	15	16	17	18	19	20	Anal II	III	10	11	12	13	14	15	16	17	18	19	Caudal vertebrae 16	17	18	19	20	21	22	23	24
crassus		1	1											1	1												1						
adelus		6			1	5								6					1	5						1	5						
afer		6		5	1									6				1	4	1						5	1						
dipharus		1				1								1							1								1				
simus		3				3								3						2	1						3						
longinarus	1								1					1									1										1

Species	Total Pectoral-fin rays 36	37	38	39	40	Total caudal-fin rays — Procurrent 6	7	8	9	10	11	Branched rays 12	13	14
crassus			1					1				1		
adelus	4	1	1			1		3					1	3
afer			2		3			2	2	2		3	1	
dipharus			1					1				1		
simus					3			1		2				3
longinarus			1					1				1		

Table 3. Gill raker counts in selected species of *Opistognathus* (Asterisks indicate bilateral counts were made).

Species	Upper gill rakers				Lower gill rakers									
	8	9	10	11	14	15	16	17	18	19	20	21	22	23
crassus			1											1
adelus		4				1	3							
afer	6					2	4							
dipharus			1							1				
simus		3							1	2				
*longinarus**	1	1					1	1						

Species	Total gill rakers												
	22	23	24	25	26	27	28	29	30	31	32	33	34
crassus											1		
adelus			1	3									
afer		2	4										
dipharus							1						
simus						1	2						
*longinarus**			1	–	1								

Table 4. Oblique scale rows in horizontal series in selected Indo-Pacific species of *Opistognathus*. (Asterisks indicate bilateral counts were made).

Species	40	42	44	46	48	50	52	54	56	58	60	62	64
	41	43	45	47	49	51	53	55	57	59	61	63	
*crassus**			2										
*adelus**	8	1	1										
afer									3	–	1		
*dipharus**											1	1	
*simus**					1	1	–	2	1	1			
longinarus	1												

Table 5. Lateral line terminus in relation to segmented dorsal-fin ray position in selected Indo-Pacific species of *Opistognathus*. (Asterisks indicate bilateral counts were made).

Species	Lateral-line terminus position						
	2	3	4	5	6	7	8
*crassus**	2						
*adelus**			5	2			
*afer**	3	4	5				
*dipharus**						1	1
simus						3	
longinarus							1

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REVIEWERS FOR BULLETINS 10, 11 and 12

Those listed below reviewed manuscripts submitted for publication in *Smithiana* Bulletins 10, 11 and 12. By giving of their time—and they are all busy people—they contributed not only to the quality of the manuscripts submitted but to the quality of the journal. The time and expertise they have generously given is hereby gratefully acknowledged.

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